M. Prevost

LOWER SANTEE RIVER

SOUTH CAROLINA

SURVEY REPORT TO DETERMINE THE EFFECTS OF DIVERSION ON NAVIGATION, IRRIGATION AND WILDLIFE

UNITED STATES ENGINEER OFFICE
CHARLESTON, SOUTH CAROLINA

SEPTEMBER 30, 1942

[redacted] CHARLESTON D.O.

SWM-6 February [redacted], 1943

Subject: Survey Report on the Lower Santee River to Determine the Effects of the Diversion of Water to the Cooper River on Navigation, Irrigation and Wildlife.

To: The Chief of Engineers, U. S. Army, War Department Building, 21st Street and Virginia Avenue, N.W., Washington, D. C.

1. There are forwarded under separate cover this date copies of the above report prepared in this office, dated September 30, 1942. The recommendation of the Division Engineer is contained in 1st Indorsement thereon, dated February 2, 1943, which has been attached as page 45 of the report. Nine tracings and nine prints thereof accompanying the report are also being forwarded this date in separate roll.

2. Two copies of the report will be forwarded by the Division Engineer together with his report.

DISPATCHED

D. W. [redacted]
Colonel, Corps of Engineers
District Engineer

CHARLESTON

Enclosures - 20
(2) copies of report (Serial Nos. 4 to 15, incl.) under sep. cover
(9) [redacted] in sep. roll

INDEX TO APPENDICES

ADDRESS:
POSTOFFICE BOX 4114

Santee Riv. 2/4.27

WAR DEPARTMENT
OFFICE OF THE DIVISION ENGINEER
SOUTH ATLANTIC DIVISION
50 WHITEHALL STREET
ATLANTA, GEORGIA

C-11/208.3 SAED-3

January 23, 1943

Subject: Unfavorable notice, Survey report on the Lower Santee River to determine the effects of the diversion of water to the Cooper River on navigation, irrigation and wildlife.

To: The District Engineer,
CHARLESTON, S. C.

1. There is herewith draft of an unfavorable notice in the case of the above report, as required by O. and R. 295. It is requested that this notice be mimeographed and distributed to interested parties.

2. Sufficient copies of the notice and mailing list will be furnished this office to supply the Office, Chief of Engineers, and the Senators and Congressmen interested.

3. The names of the Senators and Congressmen should be shown on the mailing list.

4. It is requested that the 12 additional copies of this report required by the Chief of Engineers, be furnished direct to the Chief as soon as notice has been issued, advising the Chief of Engineers that the two copies submitted to this office will be forwarded by the Division Engineer with his report. Sufficient copies of the recommendation of the Division Engineer are furnished herewith in order that a copy may be attached to each copy of the report to be forwarded to the Chief of Engineers. The nine tracings called for in the report should be forwarded direct to the Chief of Engineers.

RECEIVED
JAN 24 1943
U. S. ENGINEER OFFICE
CHARLESTON, S.C.

J. S. BRAGDON,
Colonel, Corps of Engineers,
Division Engineer.

Encls:
Draft of notice
18 copies Div. list

Subject: Unfavorable notice, Survey report on the Lower Santee River to determine the effects of the diversion of water to the Cooper River on navigation, irrigation and wildlife.

1st Ind. CCN-5

U. S. Engineer Office, Charleston, S. C., January 30, 1943.

To: The Division Engineer, South Atlantic Division, P. O. Box 4114, Atlanta, Ga.

1. Instructions contained in basic letter are being complied with.

2. There are inclosed twenty-five copies each of the notice and mailing list to supply the Office, Chief of Engineers, and the interested Congressmen.

D. W. Griffiths
Colonel, Corps of Engineers
District Engineer

Inclosures - 50
25 copies of Unfavorable notice
25 " " mailing list

See report for copy of the Page 45 of the Ind. from the Div. to C of E. Feb. 2/43

DISPATCHED
JAN 30 1943
CHARLESTON

C-11/208.3
PUBLIC NOTICE

Address:
P. O. Box 4114

WAR DEPARTMENT
OFFICE OF THE DIVISION ENGINEER
SOUTH ATLANTIC DIVISION
ATLANTA, GEORGIA

February 2, 1943

It having come to the notice of the undersigned that you have expressed an interest in the pending proposition for the improvement of Lower Santee River, South Carolina, you are hereby informed that the report thereon, authorized by a resolution of the Committee on Commerce of the United States Senate adopted April 2, 1941, has been made, and is unfavorable to the improvement. The principal grounds upon which the adverse conclusions are based are that the benefits to be expected from any practicable plan to materially reduce salting of the Santee River delta marshes would accrue largely to private property owners and would be largely intangible and insufficient to warrant the cost of the work.

You are further notified that all interested parties have the privilege of an appeal from this conclusion to the Board of Engineers for Rivers and Harbors, a permanent body sitting at Washington, D. C., to which all examination and survey reports of this character are referred. Parties desiring to do so may be heard on appeal by the board, either orally or in writing. Written communications should be addressed to the Board of Engineers for Rivers and Harbors, 2 New York Avenue, N. W., Washington, D. C., and should be mailed in time to be in possession of the said board within four weeks from the date of this communication. If, however, you have important data to communicate to the board, which cannot be collected and put in shape for proper presentation within four weeks, the board should be informed of this fact without delay and request made for an extension of the limiting date for submitting information. If oral hearings are desired, dates for the same may be arranged for by correspondence with the board.

Any further information needed may be obtained by application to this office or to the U. S. Engineer Office, 29 Customhouse, Charleston, South Carolina, but attention is invited to the following regulations as to the manner in which such information may be furnished:

> "Where interested parties desire data necessary for the preparation of their appeal to the Board of Engineers for Rivers and Harbors, they will be afforded full opportunity to examine the copies of the reports of the district and division engineers in their respective offices, subject to the understanding that no part of the contents of these reports will be published in the newspapers or otherwise until the reports have been submitted to Congress. Copies of the reports will not be furnished or loaned for use outside of the office; but interested parties will be permitted to make such notes of the contents as they desire."

You are requested to communicate the foregoing to any persons known by you to be interested in the improvement and who, not being known to this office, do not receive a copy of this communication.

J. S. Bragdon,
Colonel, Corps of Engineers,
Division Engineer.

MAILING LIST

Parties to whom were mailed on February 2, 1943, unfavorable notice on Survey repor on the Lower Santee River to determine the effects of the diversion of water to th Cooper River on navigation, irrigation and wildlife.

Chief of Engineers, U. S. Army, War Department Building, 21st Street and Virginia Avenue, N. W.	Washington, D. C.
Division Engineer, South Atlantic Division, P.O. Box 4114	Atlanta, Ga.
Commandant, U. S. Navy Yard	Charleston, S. C.
Hon. Burnet R. Maybank, U. S. Senator	Washington, D. C.
Hon. Ellison D. Smith, U. S. Senator	Washington, D. C.
Hon. L. Mendel Rivers, Member of Congress	Washington, D. C.
Hon. H. P. Fulmer, Member of Congress	Washington, D. C.
Hon. John L. McMillan, Member of Congress	Washington, D. C.
Hon. Butler B. Hare, Member of Congress	Washington, D. C.
Hon. Joseph R. Bryson, Member of Congress	Washington, D. C.
Hon. James B. Richards, Member of Congress	Washington, D. C.
Governor Olin D. Johnson	Columbia, S. C.
The Director, Fish and Wildlife Service, Dept. of Interior	Washington, D. C. and Charleston, S. C.
Washington News Service, 1700 Eye Street, N. W.	Washington, D. C.
Hon. Henry W. Lockwood, City Hall	Charleston, S. C.
City Engineer, City Hall	Charleston, S. C.
Sanitary and Drainage Commission	Charleston, S. C.
White Stack Towboat Company, Peoples Building	Charleston, S. C.
Marine Contracting and Towing Company	Charleston, S. C.
Charleston Lighterage & Transportation Company	Charleston, S. C.
Capt. Magood, #2 Doughty Street	Charleston, S. C.
Richardson Brothers, Inc., 184 East Bay Street	Charleston, S. C.
Captain Gibbs	Mt. Pleasant, S. C.
Stevens Line	Yonges Island, S. C
Carolina Shipping Company, Mid Atlantic Wharf	Charleston, S. C.
Inland Waterways Transportation Company, Prioleau	Charleston, S. C.
The North Carolina Line, Inc.	Wilmington, N. C.
The North Carolina Line, Inc., Foot of Pritchard Street	Charleston, S. C.
E. H. Jahnz, 91 Beaufain Street	Charleston, S. C.
Norfolk, Baltimore and Carolina Line, Box 780	Charleston, S. C.
The Texas Company	Charleston, S. C.
Sinclair Refining Company	Charleston, S. C.
Gulf Oil Corporation	Charleston, S. C.
Charleston Oil Company	Charleston, S. C.
Standard Oil Company	Charleston, S. C.
West Virginia Pulp and Paper Company	Charleston, S. C.
Southern Kraft Division of International Paper Company	Georgetown, S. C.
Union Bag and Paper Corporation	Savannah, Ga.
Postmaster	Georgetown, S. C.
Postmaster	McClellanville, S. C.
South Carolina Highway Dept.	Columbia, S. C.
Chairman, Federal Power Commission	Washington, D. C.
Chairman, Flood Control Coordinating Committee, 357 Admin. Bldg., Department of Agriculture	Washington, D. C.
F. M. Rast, County Agent, Clarendon County	Manning, S. C.
J. H. Harvey, County Agent, Berkeley County	Moncks Corner, S. C
M. M. McCord, County Agent, Georgetown County	Georgetown, S. C.
R. A. Jackson, County Agent, Williamsburg County	Kingstree, S. C.
Mr. R. M. Cooper, General Manager, S. C. Public Service Authority	Columbia, S. C.

Chamber of Commerce	Georgetown, S. C.
Atlantic Coast Line Railroad	Charleston, S. C.
Southern Railway System, 456 King St.	Charleston, S. C.
Seaboard Air Line Railway Co., Grove St.	Charleston, S. C.
North State Lumber Company	Charleston, S. C.
Chamber of Commerce, 50 Broad Street	Charleston, S. C.
News and Courier	Charleston, S. C.
The Evening Post	Charleston, S. C.
The State	Columbia, S. C.
The Columbia Record	Columbia, S. C.
The Field	Conway, S. C.
The Times	Georgetown, S. C.
County Engineer, Georgetown County	Georgetown, S. C.
County Engineer, Williamsburg County	Kingstree, S. C.
County Engineer, Berkeley County	Moncks Corner, S. C.
County Engineer, Clarendon County	Manning, S. C.
Dr. R. L. Sumwalt, Chairman State Planning Board	Columbia, S. C.
Mr. J. A. Gibson, Supt. South Island Plantation	Georgetown, S. C.
The Superintendent, Cat Island Plantation	Georgetown, S. C.
Mr. C. T. Bruorton, Supt., Annandale Plantation	Georgetown, S. C.
Mr. R. S. Manigault, Winyah Bay Club, 131 Tradd St.	Charleston, S. C.
Mr. T. C. Lucas, Supt. Kinloch Plantation	Georgetown, S. C.
Mr. Russell Doar	Georgetown, S. C.
Mr. J. H. Staples, Supt. Rice Hope Plantation	Georgetown, S. C.
Mr. L. Beckman, Supt. Santee Gun Club	McClellanville, S. C.
Mr. H. A. Plowden, Supt. Harrietta Plantation	McClellanville, S. C.
Mr. H. S. Shonnard, Harrietta Plantation	McClellanville, S. C
Mr. Glover, Supt. The Wedge Plantation	McClellanville, S. C.
Mr. R. L. Morrison	McClellanville, S. C.
Mr. Archibald Rutledge, Hampton Plantation	McClellanville, S. C.
College of Charleston	Charleston, S. C.
Mr. A. H. Du Pre, Refuge Mgr. Cape Romain Refuge	McClellanville, S. C.
Mr. Barney Thomas	McClellanville, S. C.
Shellmore Oyster Products Company, 150 East Bay St.	Charleston, S. C.
Mr. A. T. Schuler, Federal Game Warden	McClellanville, S. C.
Mr. T. W. Graham	McClellanville, S. C.
Mr. John H. Graham	McClellanville, S. C.
U. S. Soil Conservation Service	Washington, D. C.
C. W. Carraway, County Agent, Charleston County, Old Citadel	Charleston, S. C.
Charleston County Forest Protective Assn. Old Citadel	Charleston, S. C.
Camp Lumber Company	St. Stephens, S. C.
Santee Hardwood Lumber Company	St. Stephens, S. C.
Brooklyn Cooperage Company	Sumter, S. C.
Paul C. Seabrook, Mayor	McClellanville, S. C.
Harza Engineering Company, 27 Cumberland Street	Charleston, S. C.
State Board of Fisheries, 93 Broad Street	Charleston, S. C.
U. S. Public Health Service	Washington, D. C. and Charleston, S. C.
U. S. Forest Service	Washington, D. C.
Dr. C. Robert Lunz, Jr., Biologist, The Charleston Museum	Charleston, S. C.
U. S. Bureau of Fisheries	Washington, D. C.
Dr. E. Burnham Chamberlin, The Charleston Museum	Charleston, S. C.

file copy.

Serial No. 20

SURVEY REPORT

ON LOWER SANTEE RIVER, SOUTH CAROLINA

TO DETERMINE THE EFFECTS OF DIVERSION

ON

NAVIGATION, IRRIGATION AND WILDLIFE

NOT FOR PUBLIC RELEASE

United States Engineer Office
Charleston, S. C.
September 30, 1942

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S Y L L A B U S

The District Engineer finds that the areas bordering Santee River from Santee dam to tidewater will not be adversely affected by diversion of waters to Cooper River and, furthermore, may be benefited. Navigation, however, not needed in this portion of the stream, has been rendered impracticable, while it has been affected but slightly in the tidal reach. He finds that while the areas bordering the upper portion of the tidal reach will be affected but little, the waters in the lower portion have increased in salinity to such extent as to damage fresh-water plant life growing in marsh areas reclaimed by dikes and used as private hunting preserves. He presents a plan of improvement at an estimated cost of $594,000 which would protect these areas but finds that prospective benefits, though appreciable, would be largely intangible, would accrue principally to private interests, and therefore do not justify participation in the cost by the Federal government. He concludes that the matter is one of local concern and that the determination of justification and the equitable allocation of costs to the separate interests are matters for settlement among local interests. He recommends that no project on Lower Santee River be adopted by the Federal government at this time in the interests of navigation and irrigation and for the protection and preservation of wildlife.

UNITED STATES ENGINEER OFFICE
CUSTOMHOUSE
CHARLESTON, S. C.

September 30, 1942.

Subject: Survey report on the Lower Santee River to determine the effects of the diversion of water to the Cooper River on navigation, irrigation and wildlife.

To: The Division Engineer, South Atlantic Division, Atlanta, Georgia.

AUTHORITY

1. This report is submitted in compliance with the following authorizations:

Section 6 of the River and Harbor Act approved August 30, 1935, which reads as follows:

> "That the surveys authorized pursuant to section 1 of the River and Harbor Act of January 21, 1927, and House Document No. 308, Sixty-ninth Congress, first session, shall be supplemented by such additional study or investigation as the Chief of Engineers finds necessary to take into account important changes in economic factors as they occur, and additional stream-flow records, or other factual data."

A resolution of the United States Senate Committee on Commerce, adopted April 2, 1941, which reads as follows:

> "Resolved by the Committee on Commerce of the United States Senate, That the Board of Engineers for Rivers and Harbors, created under section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports on the Santee River, North Carolina and South Carolina, contained in House Document No. 96, Seventy-third Congress, first session, with a view to determining present conditions in the Lower Santee River, the probable effects of diversion of water from that river to the Cooper River, and whether remedial measures should be undertaken to prevent salt water intrusion in the interest of navigation and irrigation and for the protection and preservation of wildlife."

2. The investigation under authority of section 6 of the Act of August 30, 1935 was authorized by the office Chief of Engineers by fifth endorsement dated July 9, 1940, file 7249 (Santee River System)-121, subject "Practicability of Hydraulic dams across outlets of Santee River."

3. The report under review was submitted under authority contained in the River and Harbor Act, approved June 21, 1927, in accordance with House Document No. 308, Sixty-ninth Congress, first session, in the interest of navigation, power development, flood control, and irrigation. Plans were presented for the construction of nine major developments, primarily for power generation. The Chief of Engineers concluded that there was no justification for any extension of existing navigation projects, since navigation had practically ceased; that the cheapest method of flood control would be by storage in reservoirs constructed primarily for power development, but that its cost would exceed the benefits; that further development of hydroelectric power might become profitable; and that irrigation was unnecessary. He recommended that no improvement of the stream be undertaken at that time except as authorized by existing projects.

PRIOR REPORTS

4. In addition to the report under review the reports described below have been submitted.

5. A preliminary examination on "Waterway from Charleston to Columbia" was submitted by the Chief of Engineers to the Secretary of War in May 1936. The conclusion and recommendations of the Chief of Engineers were as follows:

> Completion of the maintenance work now in progress (on Santee and Congaree Rivers) will afford a usable channel of six feet depth between Charleston and Columbia (by way of the Intracoastal Waterway, Santee and Congaree Rivers.) The provisions of a through channel of 10 to 12 foot depth following either the existing channels or the proposed Santee-Cooper route would entail the construction of a series of costly

locks and dams in the Congaree. Under present conditions the savings afforded by the deeper channel desired would be incommensurate with the necessarily large expenditures required. I, therefore, report that the improvement of waterway from Charleston, S. C. to Columbia, S. C., except as heretofore authorized, is not advisable at this time.

C. A report on preliminary examination of Congaree, Wateree, Santee, and Cooper Rivers with a view to the control of floods was forwarded by the Chief of Engineers to the Secretary of War for submission to Congress March 16, 1938, File 7402 (Congaree River, S. C.)-7. The conclusions and recommendations of the Chief of Engineers were as follows:

> The most practical general plan for flood protection in the Santee River basin is one providing for the reservation of top storage in reservoirs constructed primarily for the development of power, possibly supplemented by levees in the lower basin. The reservoirs would reduce the frequency and extent of flooding of bottom lands in the lower basin, but the cost of providing added storage at power reservoirs would exceed benefits under existing conditions of development. Levees without reservoir control would be impracticable as they would have to be widely spaced to provide an adequate flood channel, leaving but a small area to be protected, and channel enlargement and rectification is not feasible due to the excessive costs involved. I, therefore, report that further studies to develop plans for the control of floods on the Congaree, Wateree, Santee, and Cooper Rivers, South Carolina, are not justified at this time, and that a survey is not warranted.

7. Senate Executive Document No. 60, 46th Congress, third session, contains reports of a survey made about 1886 for the reopening of the Santee Canal, from Santee River to Cooper River, a distance of 20 miles, with an estimate of the cost of repairing and restoring it to working condition. To restore the canal to the former condition it estimated a cost of $100,000 with $19,000 annually for maintenance, with the addition of a pumping plant to supply water to the summit section at a cost of $44,770 with $20,400 annually for operating expenses. An alternate estimate was for a deep highland cut to replace some of the locks at an estimated cost of $891,000, with $15,000 annually for maintenance.

8. The report on which the existing project for Santee River is based is printed in the Annual Report of the Chief of Engineers for 1889, page 1184.

SCOPE OF REPORT

9. This report is limited by the context of the authorizing resolution to determining conditions in the lower Santee basin prior to the diversion of water from the Santee River to the Cooper River, the probable effects of diversion of water from the Santee River to the Cooper River, and whether remedial measures should be undertaken to prevent salt water intrusion in the interest of navigation, irrigation, and wildlife.

DESCRIPTION

10. General. The basin of the Santee River system extends diagonally in a northwest-southeast direction from the coast of South Carolina between Charleston and Georgetown to the North Carolina state line and into the western part of North Carolina. It lies chiefly in the central portion of South Carolina. The greatest length of the basin is about 275 miles, and its greatest width about 115 miles. The total drainage area is 15,700 square miles, of which 10,400 are in South Carolina and 5,300 in North Carolina.

11. The basin lies in 3 well defined physiographic regions, viz., the mountain region, Piedmont Plateau, and Coastal Plain. Its northwesterly boundary is in general the crest of the Blue Ridge range, with usual elevations of 4,000 to 5,000 feet, and an offshoot of the Black Mountain range culminating in Mt. Mitchell, with an elevation of 6,711 feet.

12. The topography and geology of the mountain section of the basin are characteristic of such a region. Algonkian and Archaean rocks are exposed, and include gneiss, mica-gneiss, diorite, and granite. The Carolina gneiss is the oldest known formation in the area. River

slopes are steep and valleys generally narrow. Heavy precipitation and rapid run-off cause rapid and great variations in river levels.

13. The Piedmont Plateau extends from the foothills of the Blue Ridge Mountains southeastward to within about 100 miles of the Coast, where it falls off rather steeply to the Coastal Plain. Its general elevation is about 1,200 feet at the foothills and about 750 feet in its southeastern half. The terrain is generally rolling or hilly, but the stream slopes are flatter and the valleys generally wider than in the mountain region. The precipitation is also less, and the run-off into the streams not so rapid. The foundation rocks are similar to those of the mountain area, but in general more deeply buried under sedimentary and unconsolidated materials.

14. The Coastal Plain in turn consists of 3 principal belts. Next below the Fall line lies a chain of remarkable sand hills, about 20 miles wide, attaining elevations of 500 to 600 feet above sea level. Next toward the coast is an irregular and somewhat interrupted line of high "red hills", with elevations between 300 and 600 feet. These embrace the hills extending from Aiken County through Orangeburg to Sumter, where they are known as the High Hills of the Santee. About 70 miles from the coast, these red hills begin to merge into the coastal lands, with maximum elevations of 100 to 250 feet, and general elevations of only 10 to 50 feet, above sea level. This belt is dominated by large inland swamps and bays, and by numerous coastal streams. Rainfall increases as the coast is approached, and river bottoms are flatter, wider, and more subject to overflow. Top formations in this area are principally unconsolidated sedimentary and alluvial sands, gravels, loams, clays, muds, and marls, all lying nearly horizontal. Many sections of the coastal plain soils are very fertile and highly cultivated. The westerly sand hills, derived originally from the rocks and soils of the Piedmont Plateau and more remote mountains, are overdrained and nonproductive.

15. In this basin the Santee River is formed by the confluence of the Congaree and Wateree Rivers about 51 river miles downstream from Columbia, S. C., and flows thence 143 miles to the Atlantic Ocean. The Congaree, coming from the northwest, is formed in turn by the junction of the Saluda and Broad Rivers at Columbia. The Wateree, entering from the north, is known as the Catawba River in its upper reaches above Big Wateree Creek.

16. In its lower 18 miles Santee River is divided into two channels known as "North Santee" and "South Santee". The existing navigable channel follows North Santee. The channels through the ocean entrances are shallow, shifting and tortuous, and have not been improved. The Intracoastal Waterway crosses North Santee 4-3/4 miles above its mouth and passes on northeasterly to Winyah Bay and to Georgetown through Duck Creek and Estherville-Minim Canal; and southwesterly to Charleston through natural creeks, bays, and artificial cuts. The mean tidal range at the mouth of Santee River is 5.2 feet and at Wambaw Creek, mile 15, it is 4 feet. Before diversion tidal fluctuation extended upstream to Lenuds Ferry, mile 38. Since diversion the point of perceptible fluctuation has moved 10 miles farther upstream or to mile 48. High and low stage elevations, however, are 0.5 foot lower since diversion than before.

17. From the crossing of the Intracoastal Waterway to the head of the tidal reach at Lenuds Ferry, mile 38, the width ranges from 800 feet to 500 feet, with ordinary low water depths ranging from 20 feet to 4 feet. The stream has an easy winding course. The controlling navigable low water depths are 9.0 feet from the Intracoastal Waterway to mile 19 and thence 4.0 feet to Lenuds Ferry. The bottom and banks of this section are composed of mud, sand, and clays and the bank elevations through marsh and woodland, mostly swamp, range from 4 to 14 feet above mean low water.

18. From Lenuds Ferry to the Santee dam at mile 87 the average width is 400 feet. Prior to the construction of the dam depths at

ordinary low water ranged from 4 to 80 feet with a controlling navigable low water depth of 4.0 feet. Since the completion of the dam and the diversion of the stream the controlling navigable depth is less than 2.0 feet. The Federal Power Commission license under which this dam is operated permits diversion of all waters except a minimum discharge past the dam of 500 cubic feet per second. The banks in this portion of the stream range from 2.0 to 10.0 feet above ordinary low water.

19. The 56-mile portion of Santee River above the dam at mile 87 lies wholly within the reservoir.

20. Above the head of Santee River the streams making up the Santee River system are, Congaree River with the headwater streams Broad and Saluda Rivers which join at Columbia, forming a western arm of the system; and Wateree-Catawba River forming an eastern arm.

21. Congaree River is 51 miles long from its mouth at the head of Santee River to its head at Columbia, on the Fall Line at the confluence of Broad and Saluda Rivers. The old Federal lock and dam project is at mile 49. In the 2 miles above the dam the fall is 10.0 feet. Below the dam the fall is 41 feet, a slope of 0.83 foot per mile. The general width in the lower portion is 250 feet; in the upper portion, 350 feet. Depths range up to 20 foot with controlling depth 5 feet 5 days each week and less than 2 foot on week-ends when power plants above curtail operation.

22. Broad River from its source on the eastern slopes of the Blue Ridge Mountains near Hickory Nut Gap, N. C. at an elevation of 4000 feet, flows generally southeasterly 166 miles to its junction with Saluda River to form Congaree River. Its main tributaries are Green River, at mile 146; second Broad River at mile 119; and Pacolet, Tiger, and Enoree Rivers at miles 78, 46.5 and 42, respectively. The average slope below the mouth of Green River is 4.4 foot per mile; the headwater slopes are steeper. The maximum discharge of record was 228,000 second-foot

at Richtex, 18 miles above the mouth in October 1929. Eight power dams on the stream have little storage and little regulatory effect.

23. Saluda River from its source in the upper foot hills of the Blue Ridge Mountains in far-western South Carolina at an elevation of 880 feet flows southeasterly 145 miles to its junction with Broad River at Columbia. Its average slope is 4.5 feet per mile. Its main tributary is Reedy River to the east which parallels its course and enters at mile 76. The maximum discharge of record was 62,800 second-feet at Chappells, mile 35, in October 1929 from 1290 square miles of drainage area. There are 8 power dams on the stream. Buzzards Roost dam near Greenwood, S. C., and Saluda dam, 12 miles above the mouth and the larger of the two, were built under Federal Power Commission licenses. The latter has usable power storage of 840,000 acre-feet and has appreciable regulatory effect on the lower 12 miles of the stream and some effect on Congaree River. Buzzards Roost has 175,000 acre-feet usable power storage.

24. Wateree-Catawba River from its source in the Blue Ridge Mountains in western North Carolina about 20 miles north of the headwaters of Broad River where the stream is known as Catawba River, flows easterly about 30 miles and then southerly 215 miles to its junction with Congaree River to form Santee River. The lower 73 miles, from the mouth u to 20 miles above Camden, S. C., at the mouth of Big Wateree Creek is known as Wateree River. Below Camden the stream is navigable. The average width is 350 feet and the controlling depth for 5 days each week when the 12 power plants are operating is approximately 5 feet. The stream is practically filled with snags, logs, and debris. On weekends when power plants curtail operations the water level is lowered about 4 feet. The slope of Wateree River below Camden is 0.95 foot per mile. River stages have ranged from 1.49 at Camden during October 1932 to 40.4 during July 1916 when the discharge was 207,000 second-feet.

The 12 power dams have little storage and little regulatory effect except during periods of moderate run-off.

25. Closely associated with the Santee River system in both navigation and power through the construction of the Santee-Cooper hydroelectric project is Cooper River, a tidal estuary extending northward from its mouth at its confluence with Ashley River at Charleston, 32 miles to the junction of its East and West branches. These branches have their sources about 20 miles farther northwesterly in the flat, swampy region of Berkeley County, S. C. The main stream is bordered by marshland, with occasional bluffs 15 to 20 feet high, while the branches flow through swamps or low flat wooded land. Depths in the main stream vary from 10 feet to 35 feet, with a 35 foot deep improved outlet to the Atlantic Ocean at Charleston. In the branches, depths vary from 3 to 12 feet. The banks and bed are composed of silt, mud, and clay. The tidal range is 5.2 feet at the mouth of the river in Charleston Harbor and 4.2 feet at the Seaboard Air Line Railway bridge over the West Branch, 35 miles from Charleston.

26. Santee-Cooper project. A description of this recently constructed hydroelectric and navigation project is essential to a full description of the Santee River basin as it now exists. The description given below has been taken from the review report of the Division Engineer on Santee and Congaree Rivers for power and navigation development dated January 2, 1942, the only changes being a revision of the cost and a statement of the spillway capacity.

27. As early as 1771, the comparatively short distance between the headwaters of Cooper River and the south bank of the Santee River some 100 miles above its mouth led to a survey for a navigation canal to connect the two streams. Work on such a canal was begun in 1793 and completed in 1800. The canal was 22 miles long, 35 feet wide at the water surface and 4 feet or more deep. It was provided with 10 locks

of brick and stone and cost $750,000. For more than 50 years the Santee Canal served as an important artery of transportation but the development and competition of railroads finally compelled its abandonment.

28. The large amount of water available in the Santee River and its considerable elevation above the water level of the upper Cooper River early led to a realization of the practicability of diverting water from the Santee across the divide and using the fall to the Cooper in generating power. Beginning with a general investigation in 1915 and continuing through various steps, the plan finally bore fruit in the construction of the Santee-Cooper project by the South Carolina Public Service Authority under license of the Federal Power Commission and with funds derived in part from a loan and grant by the Public Works Administration. The project is now practically complete. The total cost of the project has been over $57,000,000. It is one of the more important hydroelectric and navigation developments in the United States.

29. The project comprises the following principal features:

a. An earthen diversion dam about 8 miles long across the Santee River at Wilson Landing, Mile 87, with a concrete spillway of 800,000 cubic feet per second capacity and provision for later construction of a navigation lock in the dam by the United States if desired. A discharge of not less than 500 second-feet is to be maintained into Santee River below the dam. A greater discharge may be required by the Secretary of War if commerce justifies it.

b. A reservoir, known as Santee reservoir, created by the diversion dam in the Santee valley, with water level ranging from 64 to 75 feet above mean sea level.

c. An earthen dam about 2 miles long across the drainage basin of Cooper River near Pinopolis, S. C., flanked by about 26 miles of earth dikes.

d. A reservoir in Ferguson Swamp, known as Pinopolis reservoir, created by the dam and dikes, with water level ranging from 60 to 75 feet above mean sea level.

e. A diversion canal about 8 miles long, 10 feet deep at minimum water level, and 200 feet wide, connecting the two reservoirs.

f. A power house and appurtenances at the Pinopolis dam.

g. A single-lift lock in the Pinopolis dam, near the power house, 60 feet wide and 180 feet long, with a depth of 12 feet over the sills. The lock has a lift of 75 feet, one of the highest in the United States.

h. A channel 14 feet deep at normal tail water level, at least 300 feet wide and 4½ miles long, from the power house to Cooper River, for tail water and navigation.

30. The Santee lake covers an area of about 155 square miles and has a maximum depth of 35 feet. The drainage area above the Santee dam is approximately 14,910 square miles. The Pinopolis lake is about 95 square miles in area with a maximum depth of 65 feet.

31. The Santee-Cooper power house is planned for an initial generating capacity of 132,615 kilowatts and an ultimate generating capacity of 163,600 kilowatts. The annual energy output during a year of average stream flow will be 700,000,000 kilowatt-hours, of which 450,000,000 kilowatt-hours will be prime and 250,000,000 kilowatt-hours secondary power. Equipment installed in the power house consists of four 40,000 horsepower turbines directly connected to four 34,000 kilovolt-ampere generators; and one 13,300 horsepower turbine directly connected to one 11,350 kilovolt-ampere generator. Provision is made for an additional future 40,000 horsepower unit.

32. In addition to the production of power by the Santee-Cooper project, the creation of the reservoir lakes and the provision of the lock in the Pinopolis dam have provided a navigable waterway at least

10 foot deep between Charleston and the head of Santee reservoir, about 57 miles downstream from Columbia, S. C. This waterway connects at Charleston with the Intracoastal Waterway, which affords 12-foot depth from Delaware Bay to Jacksonville, Florida.

33. The watershed of the entire river system comprises 15,700 square miles; the area above Santee dam comprises 14,910 square miles. The average discharge at Ferguson gage above Santee dam the wettest year of record was 30,500 second-feet in 1929; the average the driest year of record was 11,300 second-feet in 1927. The Federal Power Commission license permits the diversion of all waters down to a minimum of 500 second-feet. The planned operating discharge of the power plant will require diversion down to this minimum a long portion of the time during years of normal rainfall; and practically all of the time during years of low rainfall.

34. Santee River and basin below Santee dam, the lower portion of the stream on which the probable effect of diversion are being reported upon, comprises 390 square miles above tidewater and 400 square miles in the tidal reach. Above tidewater the area within the flood plain before diversion was 223 square miles and in the tidal reach, 89 square miles, a total of 312 square miles.

35. The tabulation which follows shows the estimated probable reduction that diversion would effect in the frequency and duration of over-bank stages at the Ferguson gage. Intermediate stages would be similarily affected. Only the larger of these floods overtop the dikes protecting the old rice fields in the delta region now maintained as hunting preserves. These would be reduced but little by diversion.

TABLE NO. 1
FLOOD DATA

Year	Natural flow		Modified flow	
	Number of times river reached over-bank stage	Duration of over-bank stage in days	Estimated number of times river would reach over-bank stage based on Santee-Cooper operating schedule	Estimated duration of over-bank stage in days
1908	11	183	4	16
1909	8	193	3	7
1910	8	101	0	0
1911	5	61	1	3
1912	8	198	2	10
1913	6	107	1	4
1914	7	94	0	0
1915	9	130	3	6
1916	5	83	2	19
1917	8	82	1	3
1918	9	81	2	6
1919	10	167	1	7
1920	7	174	0	0
1921	5	97	1	7
1922	9	184	2	5
1923	10	140	1	5
1924	10	176	1	4
1925	2	66	1	11
1926	4	78	0	0
1927	3	51	0	0
1928	10	165	3	22
1929	6	245	2	20
1930	6	72	0	0
1931	4	37	0	0
1932	11	123	1	2
1933	5	83	1	5
1934	4	43	0	0
1935	6	56	0	0
1936	11	193	5	38
1937	9	215	2	9
1938	6	31	0	0
1939	9	81	1	9
1940	2	21	0	0
TOTAL	223	3,808	41	218

36. Bridges. The following table lists the bridges which cross the portion of Santee River below Santee dam. All have been constructed under War Department permit.

TABLE NO. 2

BRIDGES

Miles above mouth	Stream	Clearance in feet			Kind	Purpose
		Vertical above		Horizontal		
		H.W.	M.L.W.			
14	North Santee R	2.8*	16.12*	68.75	Swing	Highway
11	South Santee R.	2.8	16.12	33.50	Fixed	Highway
38	Santee River	1.17*	25.1*	66.00	Swing	Railway
60	Santee River	12.40*	37.6*	49.00	Swing	Railway
65	Santee River	6.00*	34.0*	66.00	Swing	Highway

* Unlimited vertical clearance when open.

37. Maps. - The locality is shown on United States Geological Survey maps of North Carolina and South Carolina and in more detail on the enclosed map.

TRIBUTARY AREA.

38. Santee River basin below Santee dam is very largely devoted to forestry and wild life, game and wild fowl preserves occupying the lower portion of the tidal reach. There is no manufacturing. Some general farming activities are engaged in along the outer edges where lands are slightly higher. Lands generally are fertile but very poorly drained. There is no record or evidence of drainage effort though land owners have ditched fields. Forest growth consists principally of pine and the usual run of southern low land hardwoods such as cypress, gum, ash, and poplar. There is a substantial annual cut of lumber, poles, piling, veneer blocks and pulpwood, the latter use of southern pine having been established in southeastern coast states within the last 5 years. The flood plain above the tidal reach is covered with a dense growth of hardwoods with some scattered pine. Lumbering operations have been difficult due to frequent overflow from the river and only the more valuable types of timber have been cut. The reduction in the frequency and duration of flooding due to operation of Santee dam will probably result in more intensive timbering operations. Drainage, especially in the lower areas, will be improved and it is possible that portions of the area will be cleared for agricultural purposes. The fire hazard might be increased if the area should be left in its sparsely settled and relatively inactive status.

39. Santee basin below Santee dam is crossed by the Seaboard Air Line and the Atlantic Coast Line railroads, the former at river mile 38 near Jamestown and the latter at river mile 60 near St. Stephens, U.S. Highway No. 17 crosses North Santee River at mile 14 and South Santee at mile 11 near McClellanville, and U.S. Highway No. 52 crosses Santee River at mile 65 near St. Stephens. A new bridge is proposed at mile 38 near Jamestown, S.C. on S.C. Highway No. 511. In addition there are numerous country roads. For a great many years Santee River has been used very little by boats

though in early days it served as an important artery of transportation. In more recent years practically no use has been made of the stream for transportation above the tidal reach. Since diversion navigation from the dam to tide water is impracticable. There is still some movement of forest products in the tidal reach. Diversion will not affect this movement.

40. Santee basin below the dam is sparsely inhabited, the largest town being Saint Stephens which in 1940 had a population of 1,185. Other communities are Honey Hill, Jamestown, Alvin, Gourdin, and Pineville. The populations range between 35 and 100. Jamestown at the head of tidewater and on the Seaboard Air Line railroad and South Carolina highway No. 511 is strategically located with respect to the possible establishment of manufacturing that might utilize water transportation. McClellanville and Georgetown are not in the basin but are located near the preserve area. The counties that adjoin the lower Santee River and the principal cities contained in them, together with their 1940 populations, are as follows:

Counties		Cities	
Charleston	121,105	Charleston	71,275
		McClellanville	431
Berkeley	27,128	Moncks Corner	1,165
Georgetown	26,352	Georgetown	5,559
Williamsburg	41,011	Andrews	2,008
		Kingstree	3,182
Clarendon	31,500	Summerton	958
		Manning	2,381

41. Forest growth extends down to the marsh areas of the lower tidal reach. Out of a total of 312 square miles in the flood plain below Santee dam 264 square miles are in the forest area though including a small amount of open land. The principal game in the forest area are deer and wild turkey.

42. In the lower portion of the tidal reach including the coastal marshes the area is used primarily as hunting preserves. Wild duck and deer constitute the principal game. Little attention is paid to the care of deer except strict enforcement of the game laws designed to perpetuate

the stock. Duck shooting preserves, however, require large scale efforts to be successful. All preserves in the river basin including the delta are privately owned. Their management, including the expenditures made by owners in providing adequate food supplies, is of importance from the standpoint of the preservation of wild life and perpetuating this area as a winter refuge for migratory wild fowl.

43. Land values are much higher in the preserve portion of the basin than in the upper portion. Half of these lands formerly diked and irrigated for commercial rice growing are maintained as fresh water feeding grounds for migratory wild fowl, principally duck. Attention is required to insure the maximum production of food. While shooting is not permitted on areas where domestic rice is grown, it appears that this extra source of food is necessary to insure that migratory wild fowl are amply supplied with winter food. There are approximately 30,000 acres in the diked area assessed at $6 per acre on the basis of 20% of the value. At $30 value per acre the diked area represents a total value of $900,000. Adjoining areas under the same ownerships total 30,000 acres and are assessed at $2 per acre representing a total value of $300,000.

44. The abandoned rice fields in the delta area were under natural conditions before diversion ideal places for growing fresh water duck food, the water being ordinarily relatively fresh nearly to the mouth of the stream. During high tide the water surface is higher than the surrounding fields which are separated from the streams by low dikes, the tops of which are above the highest spring tides. Water can consequently be admitted to flood the fields through gates, locally known as "trunks". During low tide the water surface in the stream is lower than the fields, thus permitting drainage when necessary during this period.

45. The existing system of dikes and canals was constructed many years ago for the cultivation of rice. A very complete system of canals

and dikes containing drainage trunks traverses the fields so that individual tracts could be flooded at high tide and drained at low tide as desired. Local material consisting of a sandy silt has proven very satisfactory for dike construction, withstanding submergence by excessive storm and flood stages without serious erosion. Existing dikes are of small cross-section and are built to a height of approximately one foot above ordinary high tide. It has not been necessary under ordinary conditions for the dikes and trunks to be absolutely watertight since there has been an unlimited supply of fresh water in the river. Under conditions of increased salinity in the river water, it will be necessary to operate the trunks so as to keep salt water out of the fields, and to conserve the limited local supply of fresh water.

46. Most of the plants furnishing duck food grow only in relatively fresh waters and soils but there are valuable plants whose salinity tolerance is so great that they will grow in water almost as saline as sea water. In this report salt-content (or salinity) as found in the water samples is expressed as a percentage of that found in sea water. Sea water contains about 35,000 parts of salts per million and that is the basis on which the percentage is determined. For example, if it is said that the "salinity is 50 percent sea water" it means that it has 17,500 parts of salts per million. Salinity was determined by chemical titration. Measurements of turbidity and alkalinity or acidity of the water were not made except for a short period in 1941. Increased salinity would decrease turbidity. Sea water is so constituted that it is almost impossible for it to become acid. Consequently the effect of increased salinity would be to lower acidity. There does not seem to be any danger of acidity becoming great enough to harm plant life. Therefore a measurement of salinity is all that is necessary to indicate changes in water that are harmful to plant life. A description of the chemical titration method is given in Appendix B. A short discussion of turbi-

dity, acidity, and alkalinity; their effects on plant life and the results shown by the samples analyzed are also given in Appendix B.

47. Division between freshwater and salt-water flora. A line showing the approximate division between fresh-water and salt-water plants is shown on PLATE 53. This line would change somewhat from year to year as conditions favorable or unfavorable to fresh-water plants change. As drawn it is based on the lower limits at which fresh-water plants were found in 1941, before the closure of Santee dam. Most weight was given to the locations where wildrice was found. Based on the data obtained in this study and from United States Department of Agriculture Bulletin 634 "Food of Game Ducks In the United States and Canada", it is assumed that this line comes where the surrounding water does not exceed the equivalent of 10 percent sea water for sustained periods. The data available are not complete enough to exactly determine this percentage but it serves as a guide in determining changes in flora that will occur with changes in the salinity of the stream.

48. A brief description of the plants found in the game preserve section of the lower Santee basin that are of most value as duck food, as well as a reference to some that endanger its growth, is given below.

49. Wildrice (Zizania aquatica). This is one of the most valuable duck foods in large sections of eastern and southern United States including the area under study. It is a fresh-water plant but seems to tolerate some brackishness. On page 47 of U. S. Department of Agriculture Bulletin 634 "Food of Game Ducks In the United States and Canada" the statement is made that on the Potomac River it ranges "downstream from the fresh-water section to a point where the salt content is equivalent to about 2 to 3.5 percent of normal sea salinity during the average growing season, but at the lower limit during dry seasons the plants are frequently destroyed by increased brackishness". On page 126 of the same bulletin record is made of this plant having been found growing

where the salinity was equivalent to 20 percent sea water. These records agree in a general manner with what was found in this study. Wildrice was found growing where the soil-water salinity was equivalent to about 11 percent sea water. It was found as low as mile 3.5 on the South Santee and mile 2.5 on the North Santee River. Referring to the isochlers on PLATES 3B and 4B it is seen that during 1941 the stream was relatively fresh at these points most of the time but that salinities reached the equivalent of 50 percent sea water and held a rather high percentage for weeks at a time. Based on these references and findings wildrice will grow in slightly brackish water and will stand greater amounts of salinity for extended periods.

50. Wild millet (Echinochloa sp.). The grains of wild millet are an excellent duck food. Judging by the range through which it was found in the delta it has a salinity tolerance slightly less than wildrice. It is not abundant in this area.

51. Golden club (Orontium aquaticum); Pickerelwood (Pontoderia cordata); Wampee (Peltandra virginica); other arrowheads (Sagittaria latifolia and Sagittaria falcata). These plants are among what are commonly known as arrowheads. The above mentioned U. S. Department of Agriculture bulletin says that their value as a duck food is at best fair. However, the preserve superintendents in the area rank them as excellent foods. These plants have a tuber that serves as food. The seeds are also eaten and the plants themselves are very desirable as winter green brouse. Incidentally, the tubers of these plants are an excellent hog food. These plants have about the same salinity tolerance as wildrice.

52. Marsh hemp (Acnida cannabina). This plant has a good rating as a duck food. The seeds are eaten. It has a tolerance ranging from fresh water to very brackish water according to the aforementioned bulletin but was not found in extremely brackish water in the delta.

53. Three-square (Scirpus americanus and Scirpus robustus); Other bulrushes (Scirpus validus and Scirpus californicus). These plants are all bulrushes. The first two are three-squares which get their names from the shape of their stems which are triangular. Scirpus robustus is leafy. The latter two are round-stemmed. The seeds of all of them are excellent duck food. Scirpus americanus, validus, and californicus have about the same salinity tolerance as wildrice, and were found generally above the line of demarcation shown on PLATE 53. There was a good growth of validus and californicus near Ocean Pond and some along the north edge of Grace Island. The source of water for the growth in the vicinity of Ocean Pond is near the waterway. However, Scirpus robustus which grows abundantly in the surrounding area has a much greater salinity tolerance than the other members of this group. Its range extends from slightly above the line of demarcation drawn between fresh and salt-water plants to near the mouths of the streams. This would indicate a salinity range from an average of a few percent to an average of 50 percent or more of sea water. This upper limit is not conclusively shown by the data obtained during this study but data on PLATES 1B, 2B show high salt content for extended periods near the mouths of the streams. At times the salt content reached the equivalent of 90 percent of sea water. The tolerance of these bulrushes as found in this study agrees with those recorded in the bulletin mentioned previously in this discussion. The upper limit tolerance of Scirpus robustus is not given. On page 62 of the bulletin the statement is made that "the finest beds along the eastern side of Chesapeake Bay were found to have a salt content of from 12 to 30 percent of normal sea salinity".

54. Smartweed (Polygonum sp.). The seeds of this plant are an excellent food. Some varieties tolerate more salinity but in this area it was not found as far downstream as wildrice. Its range is from the waterway to the upper end of the delta.

55. Spikerush (Eleocharis sp.). The seeds of this plant are a good food. This is also a plant in which some varieties tolerate appreciable salinity. However, with the exception of a small stand near Ocean Pond, its lower limit was above that of wildrice.

56. Sedges (Carex sp.; Sparganium sp.). The food value of sedges is not considered as valuable as most of the others described. The seeds, and in some cases, the tubers are eaten. Their tolerance to salinity seems to be slightly less than wildrice.

57. Saltgrass (Distichlis spicata). Saltgrass grows in fresh and moderately brackish waters having a tolerance about the same as the sedges. It has a fair value as duck food but is generally not desirable because it crowds out better foods. It is not abundant in the delta and environs.

58. Pennywort (Hydrocotyle sp.). This has a fair value as a duck food. It has a salinity tolerance slightly less than wildrice.

59. Widgeon grass (Ruppia maritima). This is an excellent duck food; both seeds and the plant itself are eaten. It is strictly an aquatic plant. It has the greatest range of salinity tolerance of any of the duck foods in the delta and environs. It is found abundantly in many portions of the area ranging from the lower reaches to upper portions of the same. It is not plotted on PLATE 53. Investigators have found that this plant thrives in water having salt concentrations of from 0 to 80 percent of normal sea salinity and will live for extended periods in much greater concentrations than this. (See page 33 of "Food of Game Ducks in the United States and Canada" and "Sea-water Tolerance of Ruppia Maritima" by W. S. Bourn. The latter is published by Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.)

60. Duckweeds (Lemnaceae). This is a plant that grows in quiet fresh water. It is a good duck food the entire plants being consumed.

In the delta region it grows profusely in the old reservoirs. It is not a marsh plant.

61. Rice. As noted hereinbefore rice is planted to some extent as a duck food. Rice is very sensitive to salinity. In a report to the 68th Congress on the Sabine-Neches Waterway the statement is made that salinity in excess of 90 grains per gallon (4.4 percent by standard used in this report) will kill young rice if sustained for any length of time and considerably smaller amounts are harmful. Larger amounts are permissable for limited periods.

62. Non-food plants. Many of the plants that do not furnish food grow in the lower part of the area. Among those that grow in highly saline areas are giant cordgrass (spartina cynosuroides); saltmarsh cordgrass (spartina alterniflora); needle grass (juncus roemerianus); sea oxeye daisy (borrichia frutescens); glasswort (salicornia europea); and groundsel bush (baccharis halimifolia). Some of these have a large range of tolerance and are also found relatively far upstream. The giant cordgrass, for example, is found throughout the preserve area. The most profusely growing fresh-water plant, valueless for food, is giant cutgrass (zizaniopsis miliacea). Another non-food plant whose range is wide is cattail (typha angustifolia).

63. These non-food plants are troublesome as they often crowd out valuable ones. An increase in salinity in what is naturally fresh and slightly brackish marshes affords an opportunity for encroachment by these noxious growths.

64. Relative importance of various plants. Of the plants described above, wildrice, the three-squares, arrowheads, and widgeon grass are most valued as duck foods. They are the ones that the preserve operators try to propagate. A summary of data pertaining to plant foods found in Sabine delta is given in TABLE 3 which follows:

TABLE NO. 3

PERTINENT DATA REGARDING PLANTS
PROVIDING DUCK FOOD IN DELTA REGION

Latin name	Common name	Soil-water salinity fall 1941 percent sea water	Approx. salinity tolerance	
			Average	Maximum
Zizania aquatica	Wildrice	2.1 - 19.0	10	30
Echinochloa sp.	Wild millet	--- ---	--	--
Sagittaria latifolia	Arrowhead	3.3 - 12.5	10	30
Sagittaria falcata	Arrowhead	9.7 - 15.8	10	30
Orontium aquaticum	Golden club (a)	4.6 - 14.8	10	30
Pontederia cordata	Pickerelweed (a)	1.4 - 19.0	10	30
Peltandra virginica	Wampoo (a)	1.5 - 21.1	10	30
Acnida cannabina	Marsh hemp	--- ---	10	30
Scirpus americanus	Three-square rush	1.6 - 21.1	10	30
Scirpus robustus	Three-square rush	8.4 - 58.4	30	70
Scirpus validus	Round-stemmed rush	8.4 - 21.1	10	30
Scirpus californicus	Round-stemmed rush	3.0 - 19.0	10	30
Polygonum sp.	Smartweed	--- ---	10	30
Eleocharis sp.	Spikerush	--- ---	10	30
Carex sp.	Sedge	21.1	10	30
Cyperus sp.	Sedge	3.0 - 21.1	10	30
Sparganium sp.	Sedge	--- ---	10	30
Cladium jamaicense	Sawgrass	2.6 - 15.8	10	30
Hydrocotyle sp.	Pennywort	2.6 - 21.1	10	30
Ruppia maritima	Widgeon grass	--- ---	20	85
Lemnaceae	Duckweeds	--- ---	—	--
Non-food plants (b)	Cultivated rice	--- ---	3	10

(a) Also in arrowhead group
(b) See paragraph 62 of report

65. Oyster culture is of commercial importance along the coastal waters of South Carolina but no oysters are found near the mouth of the Santee River. Along the South Carolina Coast, oysters do best in water that ranges from 40 percent to 90 percent sea water. However, they can live for about 20 days in water as fresh as 14 percent sea water. Investigations made following the major flood of April 1936 showed that the overflow of fresh water from the river had increased the mortality rate of oysters growing in tidal streams as far as McClellanville, approximately 10 miles from the river to the south. The mortality rate was shown to have reached 90 percent in locations as much as 3 miles from the river. The low salinity resulting from river discharge and the frequency of major floods overflowing a wide area at the mouth have prevented oyster beds from becoming established in the vicinity. The area may become of some value for oyster culture.

66. Groundwater. The area studied included parts of Berkeley and Charleston Counties on the west side of Santee River and Williamsburg and Georgetown Counties on the east. Groundwater conditions are similar throughout the area.

67. In any part of this area there are several formations from which it is possible to obtain artesian water by deep drilling. The mineral content in the water from these strata varies considerably, although in general it may be stated that the deeper the water bearing stratum, the less mineral matter the water will carry in solution. These water bearing strata are the Santee limestone, the Black Creek formation, the Pee Dee formation, and the Tuscaloosa formation, all of Upper Cretaceous Age.

68. In Charleston County the Santee limestone has yielded artesian water at a depth of 425 feet; the Pee Dee has yielded water at a depth of 1,260 feet; and the Black Creek has yielded water at a depth of 2,000 feet. The Black Creek water-bearing stratum has been found at depths of

less than 600 feet in Georgetown County and of less than 500 feet in Williamsburg County. The U. S. Geological Survey states that in Berkeley County it is likely that artesian water can be found at any place at depths of less than 400 feet. In all of these counties the as yet untapped Tuscaloosa is available at greatest depths.

69. Artesian Wells. In summary we find that artesian water-bearing strata underlie this whole area; that this water occurs at depths varying from less than 400 feet up to 2000 feet; and that the deeper the water-bearing stratum the less mineral matter the water will carry in solution. There are two artesian wells in the area, one on Rice Hope plantation and the other on South Island. The one on Rice Hope plantation is 2 inches in diameter and 662 feet deep; the one on South Island plantation is believed to be the same diameter, and approximately the same depth. These yield from 20 to 25 gallons a minute. At both places the water has been tested and found unsuitable for plant growth.

70. Drainage areas. Pertinent drainage areas of the Lower Santee, tributaries of this river near the mouth, and of the Cooper River are given below:

TABLE NO. 4

DRAINAGE AREAS

	Location	Drainage area
Santee River	Ferguson	14,800
do	Wilson Landing	14,910
do	Botaw Landing	15,190
do	Lenuds Ferry	15,300
do	Highway 17	15,600
do	Mouth	15,700
Cedar Creek	Mouth	25
Wambaw Creek	Mouth	68
Wadmacon Creek	Mouth	35
Cooper River	Mouth	790

METEOROLOGY AND HYDROLOGY

71. The climate is typical of the warm temperate zone with a mean annual temperature of 65 degrees and recorded extremes of 107 and -3 degrees Fahrenheit. The growing season averages 260 days a year. The well distributed rainfall, which is discussed more fully hereinafter, averages about 50 inches a year.

72. Precipitation. Though the precipitation record at Charleston, just outside Lower Santee basin, is one of the oldest in the world, having been started in 1738, complete records within the watershed do not date back earlier than 1894.

73. The average annual rainfall in Santee basin below the dam is substantially the same as above the dam, viz. 49 inches. The maximum occurred in 1924 and amounted to 64.84 inches. The minimum occurred in 1933 and amounted to 33.44 inches. Gage locations are shown on PLATE 1 and pertinent data are given in TABLES 5 and 6 below:

TABLE NO. 5

PRECIPITATION

Station (a)	Record started	Years of record	Average annual precipitation in inches
Charleston	1738	170	45.22
Ferguson	1886	54	48.90
Georgetown	1894	45	51.10
Kingstree	1883	60	47.02
Summerville	1898	44	49.96
Pinopolis	1846	95	49.87

(a) All these stations are in operation at present.

TABLE NO. 6

AVERAGE MONTHLY PRECIPITATION
IN INCHES

Month	Precipitation in inches						
	Charleston	Summerville	Ferguson	Georgetown	Kingstree	Pinopolis	Average*
January	3.02	3.06	3.50	3.38	3.14	2.84	3.22
February	2.98	3.67	3.65	3.91	3.57	3.62	3.69
March	3.02	3.29	3.36	3.43	3.49	3.34	3.40
April	2.53	3.41	3.31	3.17	3.07	3.23	3.19
May	3.00	3.53	3.83	3.86	3.20	3.94	3.71
June	4.59	5.78	5.70	5.99	5.46	6.07	5.80
July	6.89	6.97	6.75	7.41	6.75	7.49	7.10
August	6.53	6.66	6.38	6.29	5.91	6.27	6.21
September	4.53	5.00	4.26	4.64	4.37	4.57	4.46
October	3.27	3.05	2.94	3.04	2.86	3.12	2.99
November	2.14	2.22	2.06	2.43	2.08	2.34	2.23
December	2.72	3.33	3.16	3.55	3.12	3.04	3.22
Average annual	45.22	49.96	48.90	51.10	47.02	49.87	49.22

* Average rainfall over lower Santee River watershed. Charleston and Summerville values are not included in averages.

74. Storms. Tropical hurricanes with the accompaning rainfall cause greater damage than any other type that occurs in the area. Extremely heavy rainfall sometimes centers in or near the lower basin as, for example, on July 14-15, 1916, when the precipitation totaled 16 inches at Kingstree, South Carolina. However, the heavy rainfall on the tributaries of the Santee River during these storms is the cause of the great floods in the lower basin. The general winter rains also cause inundations but they are not nearly so severe as those resulting from the hurricanes.

75. The lower reaches of the area are also inundated by exceptionally high ocean tides caused by hurricane winds. The most disastrous inundation by hurricane tides occurred on September 27, 1822. Over 100 persons, mostly slaves, were drowned on Murphy Island. The inscription on a gravestone in Santee Churchyard states that victims of the memorable hurricane of that date are buried there. The plantation owners constructed brick structures large enough to house the lowland residents, with floors well above the highwater mark, to prevent loss of life if a great flood should recur.

76. There are no other disastrous high tides of record until that of 1886 caused by an earthquake. Other notable high tides, hurricane induced, occurred in 1893, 1911, 1916, and 1940. That of 1893 may have been more severe than that of 1822, no positive highwater marks being established for either. That of 1911 is not believed to have been as severe as some of the others. That of 1940 is of interest only because of its recent occurrence.

77. The flood of July 1916 is best remembered by the present inhabitants. A description based in part on memory and part on diary records is given below.

78. At about 1 p.m. on July 13 a strong wind started from the east, accompanied by heavy clouds. By nightfall it had developed into one of the worst storms known in the region. The tide water covered the marsh and part of the woods in the vicinity of the Santee Club wharf and other areas of the same elevation. With a change in the wind, the high water receded. About 10 days later the flood resulting from the heavy rainfall on the upper basin came down, reaching a stage somewhat higher than that of the storm tide and with the high stage lasting much longer. An example of the crop damage resulting was given by a resident who had about 150 acres of rice that were inundated by the storm tide. Heavy rainfall after the tide receded apparently helped mitigate any harmful results from the saline inundation and the prospects for a large yield seemed excellent. However, the long submergence in mud laden waters from the flood which came down a few days later from the watershed above lower Santee basin completely destroyed the crop.

79. Run-off. On the total area above the Ferguson gage 35 percent of the precipitation appears as run-off, the average annual run-off being 17.4 inches. On the area below Santee dam it is estimated that 25 percent of the precipitation appears as run-off, amounting to 12.5

inches in an average year and to 8.3 inches in an exceptionally dry year such as 1933. It is estimated that the discharge from the area below the dam will equal or exceed 1,800 cubic feet per second an average of once a year, 2400 cubic feet per second once every 2 years and 4100 cubic feet per second once every 10 years. These discharges will hold for periods averaging 1 month. The large amount of channel storage in the stream bed in relation to the run-off from the area below the dam will tend to prevent high peaks from local run-off. Furthermore, the run-off occurs mainly during the winter months when the rains are general but not excessively heavy. It is estimated that a flood having a volume of 1 inch or more of run-off from the area below the dam will occur 100 times in 100 years during December through February; 65 times in the same period from March through May; 10 times during September through October; and seldom during June through August. These estimates are based on rainfall and run-off records for the area under discussion and on comparison with records from other areas in the same region. A volume frequency curve for the Black River near Kingstree, South Carolina, is shown in Appendix A. A fuller discussion of the basis for the estimates is given in the same appendix.

80. The stages of 4 large recent floods, those of 1908, 1916, 1929, and 1936, have been determined in the delta region at the Santee Club landing at mile 7.6 on South Santee River. These floods reached heights of 9.1, 9.8, 8.8, and 9.0 feet respectively above mean low water, or 5.2, 5.9, 4.9, and 5.1 feet respectively above mean high water. It is estimated that if the Santee-Cooper project had been in operation the stages would have been only a few tenths of a foot lower. A tabulation of the natural peaks of great floods at Ferguson and the estimated reduced peaks that would result from the effects of Santee-Cooper reservoirs are given in TABLE NO. 7 which follows. Methods used in estimating the reduced peaks and the rating and frequency curves are described in Appendix A.

TABLE NO. 7
FLOOD DATA AT SANTEE DAM

Recorded floods tabulated according to size			Recorded floods tabulated according to months of occurrence	
Date	Peak discharge at Ferguson, S. C. D.A.=14,800 sq. mi.	Peak discharge modified by Saluda development	Peak discharge modified by Saluda and Santee-Cooper developments	Months	Number of floods
July 22, 1916	368,000	368,000	337,200	January	1
Aug. 31, 1908	344,000	344,000	313,400		
Oct. 7, 1929	260,000	260,000	229,400	February	3
Aug. 22, 1928	248,000	239,100	208,500		
Apr. 11, 1936	242,000	242,000	211,400	March	4
March 21, 1912	209,000	196,200	165,600		
March 10, 1929	155,000	140,400	109,800	April	1
Feb. 16, 1921	149,000	134,400	103,800		
July 27, 1919	146,000	131,500	100,800	May	0
Jan. 23, 1925	143,000	128,500	97,900		
Sept. 24, 1928	125,000	111,100	80,500	June	1
Sept. 11, 1928	122,000	108,300	77,700		
Feb. 9, 1916	104,000	91,100	60,500	July	2
Feb. 21, 1922	101,000	88,400	57,800		
June 10,1909	101,000	88,400	57,800	August	2
March 21, 1918	98,000	85,600	55,000		
Oct. 5, 1924	92,000	82,400	51,800	September	2
March 25, 1925	89,000	77,200	46,600		
				October	2
				November	0
				December	0
					18

EXISTING PROJECT

81. The existing project is one for maintenance and provides for snagging the entire river. It was adopted by the River and Harbor Act approved September 19, 1890 (Annual Report for 1889, p. 1184). The plane of reference for the tidal section is mean low water, the mean tidal range at the mouth being 4.5 feet. Above the tidal reach the plane of reference is ordinary low water. Prior to diversion the controlling depth was 9.2 feet from the Intracoastal Waterway to mile 19 and thence 4 feet to the head of the river; the variation in water level was 25 feet at Ferguson, 101 miles above the mouth. The upper 56 miles of the

river are now covered by the reservoir. Diversion of all but 500 second-feet has lowered the plane of ordinary water approximately 7 feet just below the dam and approximately 3 feet at Lenuds Ferry, the former head of the tidal reach. Tidal fluctuation is now perceptible 10 miles farther upstream than under pre-diversion conditions, or to a point approximately 48 miles above the mouth. The costs of the existing project to June 30, 1942, have been $173,667.65, chargeable to maintenance.

82. No project for flood control has been adopted for Santee River. Operation of Santee reservoir for power production will have an appreciable regulatory effect as shown in former paragraph 35 herein.

83. Local cooperation. - Local cooperation is not required under the existing project for Santee River.

84. Other improvements. - Private interests and successively Colonial, State, and Federal governments have undertaken improvements within the river system. Although the project works constructed by the State about 1820 on Saluda and Broad Rivers do not appear to have played the part in commerce expected by their designers, one portion is maintained by a local power company. The Santee Canal, connecting Santee and Cooper Rivers, was completed in 1800 by private capital and was operated until 1850. The Federal government has undertaken the snagging of Santee, Wateree, and Congaree rivers during the periods in which the commerce has justified the expenditure of funds and has provided a connection with Winyah Bay. The first connection was through Mosquito Creek Canal and, later, through Estherville-Minim Creek Canal, further inland. This is now a part of the Intracoastal Waterway. The Santee-Cooper hydroelectric project is fully described in preceding paragraphs 26 to 33, inclusive. An extensive system of dikes and drainage canals was built many years ago by private land owners in the tidal marshes along the lower reaches of the river primarily for rice culture. These have been maintained in operation in late years to provide winter feeding grounds for migratory fowl.

85. Terminal and transfer facilities. At the present time the only terminal on the river is a pulpwood loading terminal located in the tidal reach, 23 miles above the mouth. Three pulpwood terminals formerly in use near Ferguson have been flooded out by the filling of Santee reservoir.

IMPROVEMENT DESIRED

86. In order to determine the views of interested parties a public hearing was held at Georgetown, S. C., on February 2, 1942. Copies of the stenographic report of the hearing and of exhibits are attached hereto.

87. The hearing was well attended. Among those present were representatives of the Fish and Wildlife Service of the Department of the Interior; the Federal Works Agency; the Public Works Administration; the United States Forest Service; the South Carolina Public Service Authority; the Georgetown Chamber of Commerce; the Georgetown County Commissioners; the Harza Engineering Company; the Atlantic Coast Line and the Seaboard Airline Railroads; owners, superintendents and other representatives of plantations and game preserves in the delta region; and reporters for Georgetown and Charleston newspapers.

88. The consensus of opinion of plantation owners and representatives is that with diversion of all but 500 second-feet of the flow of Santee River into Cooper River intrusion of salt water is inevitable throughout the Santee delta with disastrous effects to fresh-water plants which thrive in the old rice fields and furnish winter feeding for wild ducks and other migratory fowl. One plantation owner stated that fresh-water should be supplied by digging a canal from Cooper River at a cost of $5,000,000. The owner of a plantation situated on Wambaw Creek one-half mile from South Santee River stated that since diversion the level of the tides had been lowered so that he cannot irrigate his fields but that he would settle his claims for an artesian well that would keep his

reservoir fresh. The representative of a plantation situated near the mouth of North Santee River suggested that the mouth of Mosquito Creek at North Santee River be dammed and access for boats and fresh water to the plantation be provided by Cheney Creek from its mouth in Minim Creek at the south end of Estherville-Minim Creek Canal and thence through connecting branch canals. This would furnish water from the Estherville-Minim Creek Canal which he expects will be fresher than that in North Santee River at the mouth of Mosquito Creek.

89. The General Counsel for the Federal Works Agency outlined the history of Santee-Cooper project and stated that the questions at issue had been decided when the Federal Power Commission granted the license and that the Secretary of War had passed favorably on the development. He further stated that no private citizen has any property interest in navigation or migratory wildlife but that a landowner who believed himself damaged could seek a settlement with the South Carolina Public Service Authority and if this was not satisfactory he had recourse to the courts since the law and the Constitution guarantee the property rights of individuals. He said that the United States expended a total of $57,025,000 on the Santee-Cooper project through the Federal Works Agency and that this agency holds bonds, to the amount of $26,000,000, of the South Carolina Public Service Authority. He further stated that it was not the place of an agency of the Federal government to develop evidence for a citizen to use in bringing suit against a state agency. He brought out the value of power in producing implements of war and expressed the opinion that the Secretary of War through the Corps of Engineers would not suggest remedies that would hamper the war effort.

Nor against Federal Govt Utility

90. The General Counsel for the South Carolina Public Service Authority stated that water had not been diverted long enough to determine whether or not there would be any damages but that the general

position of the Authority was that there would be none. He said that any landowner who felt that he was damaged could deal directly with the South Carolina Public Service Authority. He asked what commercial use was being made of the land on which damages were claimed. Both he and the General Counsel for the Federal Works Agency asked permission to file data later if they so desired. They were told that this was permissible but no data were subsequently filed.

91. Subsequent to the public hearing letters were received from the Fish and Wildlife Service of the United States Department of the Interior stressing the value of the Santee delta as winter feeding grounds for migratory ducks, particularly in view of the inadequate food supply on the nearby Cape Romain Migratory Bird Refuge. The letter of April 22, 1942, from the acting Chief, Division of Wildlife Refuges, sets forth that replacement of 50,000 acres at assumed costs of $4.00 for land and $10.00 for improvement, a total of $700,000, is far in excess of the cost of dikes across the mouth of Santee River. Opposition to this plan was expressed by the superintendent of a plantation near the mouth of the river since in his opinion it would prevent drainage of the diked fields and would increase flood heights.

92. No desire has been expressed by local interests for improvement of lower Santee River for navigation.

COMMERCE

93. The annual movement of commerce on Santee River from 1890 to 1907, inclusive, averaged 195,245 tons valued at $2,169,886. From 1908 to 1929, inclusive, the annual movement averaged 48,937 tons valued at $521,842. The major commodities handled consisted of wood and timber products, cotton and rice, with the first named making up 89 percent of the total. Commerce practically ceased on the river during the 8-year period from 1930 through 1937, the only commerce reported being 155 tons in 1931, 1745 tons in 1936, and 82 tons in 1937. Downstream barge

movement of pulpwood to mills at Charleston and Georgetown and an upstream movement of fuel oil and construction equipment used on the construction of Santee dam commenced in 1938, the annual average for the 4-year period through 1941 being 15,112 tons. Prior to the closure of the dam pulpwood moved from landings near Ferguson; since that time the only movement has been from a landing in the tidal reach, 6471 tons being moved during the first 6 months of 1942. Details of the 1941 commerce are given in TABLE NO. 8 which follows:

TABLE NO. 8
1941 Commerce
Santee River

Commodities	Tons upstream	Tons downstream
Pulpwood	---	11,884
Steel pipe	500	500
Deisel oil	7	---
Fuel oil	5,291	---
Totals	5,798	12,384

94. Vessel traffic. The 1941 commerce was carried in 22 trips by barges having a loaded draft of 6 to 8 feet, handled by tugs drawing 6 feet. In addition there were 1,555 trips by motor vessels drawing 4 to 5 feet which carried 105,020 passengers engaged in clearing operations in Santee reservoir area.

95. Prospective Commerce. Under the new conditions of variable river stage below Santee dam commercial navigation from the dam dam to the head of the tidal reach is impracticable. Recent commerce on the tidal section has been limited to barge shipments of pulpwood to a pulp mill at Charleston. It is probable that for a time, possibly a decade, only timber products in limited volume will be shipped on Santee River below the dam. This movement will be limited to the tidal reach. It is not probable that there will be any need in the future for commercial movement above tidewater. In view of the favorable connection between tidewater and highway and rail transportation at Jamestown, the estimated

great reduction in river flooding, and the stated policy of the South Carolina Public Service Authority to invite and encourage power using industries through low power costs, it is possible that ultimately the tidal reach may become an important feeder project to the Intracoastal Waterway.

96. Difficulties attending navigation. There are no unusual difficulties attending navigation in the tidal reach of Santee River. In the 49 mile portion of the stream from the head of the tidal reach to the dam, the discharge will range from 500 cubic feet per second immediately below the dam and 700 at the head of tidewater upward to several thousand, depending upon the power demand at the Pinopolis power house and the run-off from the watershed above the dam. Controlling channel depth would range from less than 2.0 feet to 6.0 feet and over. Forecasting discharge and controlling depth with any degree of accuracy is impracticable.

97. Water power. There is no practical possibility for the development of water power on lower Santee River.

SURVEY

98. Surveys and investigations of several kinds were made by this office. Recording stream gages were established and maintained for various periods at several places between a point near the mouth of North Santee River and Wilson Landing. The stations above tidal influence were rated with a current meter. Miscellaneous current meter measurements were made in the tidal section. Water samples were collected and analyzed. Information to reinforce that obtainable from available maps on dikes, canals, ponds and other physical data and elevations enough to determine topography in the lower delta region were obtained. Data on the area above the tidal reach are based largely on recent surveys made in connection with maintenance of the existing project. Data on the flora of the delta region were obtained in cooperation with the Fish and Wildlife Service.

Representative landowners, public officials, and others were interviewed throughout the area including representatives of all of the game preserves in the delta region. A general map and profile is shown as PLATE 1 of this report and other plates are included in the Appendices.

PLAN OF IMPROVEMENT

99. An analysis of the effects of diversion on the lower Santee River and basin shows that economic justification for any remedial measures to prevent salt water intrusion must rest upon the benefits to the winter feeding grounds of migratory wild fowl located in the extreme lower portion of the tidal reach.

100. A number of possibilities including all plans suggested by local interests have been given due consideration. Black River to the eastward has insufficient discharge to furnish the needed supply of fresh water. Diversion of fresh water from Pinopolis tail canal cannot be practically undertaken since the fall from the tail canal to Santee basin is too little. Barrier dams across the mouths of North Santee and South Santee Rivers would be costly and would probably not accomplish the desired results without costly appurtenant and auxiliary works. Some type of solid structure would be required at channels to withstand the effects of the rapid recession of ocean waters that might be piled up above the dam during storm and of large floods from the upper watershed. Without regulating gates the river water, particularly during floods, would be raised to destructive heights. The influx of salt water through the Intracoastal Waterway without salt water locks would tend to nullify the effects of barrier dams. Without locks in the Intracoastal Waterway usable fresh water would be lost. Rock fill dams across the two main channels would cost at least $1,500,000 without the regulating gates. This cost, alone, is excessive. In view of the change in lower Santee River water from fresh to salt the perviousness of the existing dikes and their limited height render impracticable the adoption of the existing system with new work restricted to providing new fresh water supplies.

101. Enlarging and strengthening the existing system of dikes surviving from commercial rice planting days appears to offer material results. This plan contemplates reconstruction of the existing dikes along the river and principal creeks to a height of 6 feet above mean sea level or about 2 feet above normal high tide. A top width of 6 feet and side slopes of one and one-half feet horizontal to one foot vertical are contemplated. The entire system would comprise 114 miles of dikes requiring 770,000 cubic yards of new fill allowing 15 percent for shrinkage. This amount is in addition to approximately 190,000 cubic yards of material now in place in existing dikes and which would be incorporated in the enlarged dikes. A total of 100 gated trunks would be required. The location of the proposed dike system and a typical cross-section of the proposed dikes are shown on PLATE 2C.

102. Cost estimates are based on a unit cost of 50 cents per cubic yard of embankment, including an allowance of 10 cents per cubic yard for clearing and stripping. Gated conduits through the dikes are estimated to cost $350 each. Detailed plans of small earth dams to create ponds of fresh water within the diked areas have not been prepared but it is estimated that the cost would not exceed $20,000. A summary of first costs is given below:

Dikes, 770,000 cu. yds. @ $0.50	$385,000
Gated conduits, 100 @ $350 each	35,000
Earth dams for small reservoirs and ponds	20,000
TOTAL	$440,000
Engineering, contingencies and overhead, 35% . .	154,000
TOTAL FIRST COST	$594,000

103. Annual charges. Annual charges are given below computed on the basis of improvement by private interests and also on the basis of improvement by the Federal government. Interest and amortization for improvement by private interests are based on a rate of 4 percent; for improvement by the Federal government, a rate of 3 percent.

The useful life of the improvement is taken to be 50 years. Annual maintenance is estimated at 2 percent of the first cost.

Estimated annual charges using private capital are:

Interest, $594,000 @ 4%	$23,760
Amortization, $594,000 @ 0.655%	3,890
Maintenance	12,000
TOTAL ANNUAL CHARGE	$39,650

Estimated annual charges using Federal funds are:

Interest, $594,000 @ 3%	$17,820
Amortization, $594,000 @ 0.89%	5,280
Maintenance	12,000
TOTAL ANNUAL CHARGE	$35,100

DISCUSSION

104. In the portion of the Santee basin between the dam and tidewater the effects of diversion are limited generally to the channel and the flood plain and its immediate vicinity. Former river stages will be practically eliminated. The matter of the intrusion of salt water does not enter into the situation. Drainage in the flood plain and its immediate vicinity will be greatly facilitated. The fire hazard will be increased through a general drying-out of the basin. Drying-out will not be harmful to forest growth, cultivated land, nor wildlife. Firm ground will facilitate lumbering. Established methods of combating the fire hazard can be resorted to and possible clearing and settlement will aid. Through the improved drainage situation a large portion of the area may be devoted to agriculture, the lands being of a type generally fertile when properly cleared and aerated. Two through railroad lines and their branches and two main improved highways are adequate for the needs of extensive development of the area. This portion of the basin could, on the other hand, be considered as a forestry and wildlife preserve and be administered by either a local taxing district or the State or Federal

government. The areas bordering the stream from the dam to tidewater will not be injured and may be benefited.

105. In the river channel above tidewater the navigability has been practically eliminated. While there will be intermittent short intervals when 4 feet of water, or over, will be available, this cannot be considered navigable depth. There is, however, no need for navigation in this 49 mile portion of the stream. The bordering area is sparsely settled and the commodities that will move in and out of the basin are in convenient reach of Georgetown and Charleston by land methods of transportation and also in convenient reach of the head of tidewater. Through water traffic from the basin above the dam, in the event such is developed, will have access to the seacoast through the Santee-Cooper project works and Cooper River.

106. In the tidal reach the existing project is adequate for the immediate needs of navigation. The reach is susceptible to further improvement without unusual difficulty, should the availability of low-cost power from Santee-Cooper project result in the establishment of manufacturing enterprises at the head of tidewater where the Seaboard Air Line Railroad crosses. Such prospects are, however, remote at this time.

107. Based on observations made during the present investigation it is not probable that the intrusion of salt water will extend far enough upstream to affect the heavy forest growth in the upper portion of the tidal reach. Drainage will be affected but slightly and that near the head of the reach. In the lower portions of the tidal reach where an appreciable increase in salinity has occurred, only scattered forest areas will be affected, mostly fringes along the immediate shores of the river and its main tributaries. The total area affected is so small as to be negligible.

108. In seasons of heavy rainfall local run-off is ample to maintain fresh water conditions in the diked fields in the lower tidal

reach and the fresh water in the river will not be needed. Furthermore, during dry seasons when local fresh water supplies are at their lowest it is improbable that more than the required minimum will be released at Santee dam. It is improbable, therefore, that the stages of river above the extreme low stage which will occur with varying frequency will be of measurable benefit. The areas are privately owned and are used as shooting preserves. Valuable winter homes are on some of the preserves. The present values of the diked areas will be seriously depreciated by salt water intrusion unless a new supply of fresh water is provided and dikes improved. Otherwise the area will revert largely to salt marsh. As such they would be less extensively visited by migratory wild fowl due to the lower food producing capacity per unit area, and would therefore be of correspondingly less value and benefit.

109. While the wild salt marsh areas along the coast furnish food and are utilized by wild fowl, they do not furnish food in the abundant quantities per unit area that the privately owned and tended areas furnish. The need for fresh water feeding grounds to supply additional food has been recognized at Cape Romain Refuge where small areas roughly estimated to total approximately 800 acres have been provided. The diked fresh water feeding grounds along lower Santee River are an asset to Cape Romain Refuge.

110. The only practicable over-all plan of improvement appears to be that presented in paragraph 102 herein to enlarge and extend the existing system of dikes and develop local fresh water supplies at an estimated first cost of $594,000 and annual maintenance of $12,000.

111. The benefits from this improvement though probably appreciable would be for the most part recreational and intangible and would accrue principally to the owners of the diked fields. Local benefits of small value would consist of property taxes, profits on trade and some little employment. The only benefit to the general

public from the preservation of these feeding grounds would consist of that derived from the preservation of wildlife on a national scale. No monetary unit of measure of the value of wildlife has been developed in this study. The Acting Chief, Division of Wildlife Refuges of the Fish and Wildlife Service, stated in his letter of April 22, 1942, "....it is almost impossible to place a dollar-and-cents appraisal upon this valuable wildlife area."

112. It is logical to assume that not a few of the owners of the damaged fields will take the initiative and employ methods of their own choosing to preserve the endangered fields. Such work has been started by one or two owners. It is probable that methods acceptable to individuals would possess hazards to usefulness and permanency which would not be acceptable in a total-area plan such as that proposed in this report. Possible methods consist of the development of local supplies of fresh water and patch work on the existing dikes. In view of the attorneys' statements at the public hearing, it is also logical to assume that claims will be filed to cover damages from salt water. These claims might include amounts to cover the cost of the work undertaken privately to preserve the fields.

CONCLUSIONS

113. Navigation will be affected but slightly in the tidal portion of Santee River and is not required in the reach between tidewater and the dam where diversion has rendered navigation impracticable. Areas bordering the portion above tidewater will not be adversely affected and may be benefited through diversion. In the tidal portion of the stream areas beyond the flood plain will be affected but slightly. Salt water intrusion, however, will seriously affect fresh-water plant growth in diked fields used as private hunting preserves unless remedial measures are undertaken. Enlarging and extending the existing dikes along the river and major creeks to afford protection to all the diked areas

appears to be the most suitable plan. Benefits from such improvement, largely recreational and intangible, would accrue principally to private interests. The uncertain intangible benefits to the general public would not be sufficient to justify Federal participation in the cost of improvement. It is finally concluded that the matter is one of local concern and determination of the justification and the equitable allocation of costs based on proportionate benefits to be derived by the separate interests are matters for settlement among local interests. These interests include the Federal ownership of the Cape Romain Refuge.

RECOMMENDATION

114. It is therefore recommended that no project on Lower Santee River be adopted by the Federal government at this time in the interest of navigation, irrigation, or the protection and preservation of wildlife.

D. W. Griffiths,
Colonel, Corps of Engineers,
District Engineer.

Inclosures - 27
Notice of Public Hearing
List of Parties to Whom Sent
Transcript of Public Hearing
Exhibits A, B, and C
Appendices A, B, and C
9 Tracings)
9 Prints)——Separate Roll

NOT FOR PUBLIC RELEASE

Subject: Survey report on the Lower Santee River to determine the effects of the diversion of water to the Cooper River on navigation, irrigation and wildlife.

C-11/208.1 1st Ind. SAKE-3

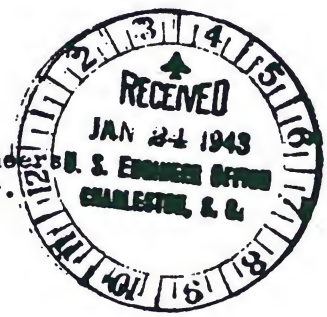
Office, Div. Engr., South Atlantic Div., Atlanta, Ga., FEB 2 1943

To: The Chief of Engineers, U.S. Army, Washington, D. C. Attention: Civil Works

1. The report shows that salting of the Santee River delta marshes has been caused by the diversion of the flow of the Santee River through the Santee-Cooper development. The Division Engineer agrees that the only practicable plan for counteracting that salting is that described by the District Engineer, namely, diking the affected areas and depending on local rainfall and occasional floods to maintain fresh water conditions on the areas suitable for the growth of food plants. The cost of such improvement is estimated at $600,000.

2. The Division Engineer agrees that the benefits from such an improvement would be largely intangible, and would accrue chiefly to the owners of private hunting preserves in the area. He considers that the question of damages to the properties is a matter for adjustment between the owners and the South Carolina Public Service Authority. He believes that the destruction of food-producing plants in the Santee Delta may have an adverse effect on wildlife, but does not consider it practicable to counteract this effect by improving privately-owned property.

3. The Division Engineer accordingly concurs in the recommendation of the District Engineer.



J. S. BRAGDON,
Colonel, Corps of Engineers,
Division Engineer.

Incls:
Notice of public hearing (in dup)
List of parties to whom sent (in dup)
Transcript of public hearing (in dup)
Exhibits A, B, and C (in dup)
Appendices A, B, and C (in dup)
9 tracings & 9 prints (sep. roll)
17 copies unfavorable notice
2 copies mailing list

INDEX TO APPENDICES

SURVEY REPORT

ON LOWER SANTEE RIVER, SOUTH CAROLINA

TO DETERMINE THE EFFECTS OF DIVERSION

ON

NAVIGATION, IRRIGATION AND WILDLIFE

A P P E N D I C E S

APPENDIX A - HYDROLOGY

APPENDIX B - SALINITY

APPENDIX C - PLAN OF IMPROVEMENT

United States Engineer Office
Charleston, S. C.

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APPENDIX A

HYDROLOGY

1. Stream gaging stations. On the Santee River at Ferguson South Carolina, drainage area 14,800 square miles, the United States Geological Survey established a stream gaging station on September 21, 1907. Average daily discharge records are available from December 1907 until November 1941 when the backwater from the Santee dam resulted in the discontinuation of the gage. Construction of a new gage below the Santee dam is now in progress. During the construction of Santee dam the Harza Engineering Company erected a temporary staff gage below the dam where daily readings have been taken. This office established five recording stream and tide gages between the Santee dam and the mouth of the Santee River. These gages are located at Wilson Landing, Betaw Landing, Lenuds Ferry, highway bridge (U. S. Route 17), and on the North Santee River at its intersection with the Intracoastal Waterway. A tabulation of the stations and periods of record is given in TABLE 1A.

TABLE 1A

STREAM AND TIDE GAGING STATIONS

Location	Type of gage	Drainage area square miles	Period of record	
			Before salinity observations	After salinity observations
Ferguson	R	14,800	Dec. 1,1907-May 20,1941	May 20,1941-Nov.13,1941
Wilson Landing	staff	14,910	Jan. 3,1940-May 20,1941	May 20,1941-date
Wilson Landing	R	14,910	Oct. 10,1940-Dec. 20,1940	June 12,1942-July 30,1942
Betaw Landing	R	15,190		June 3,1942-July 30,1942
Lenuds Ferry*	R	15,300	Oct. 7,1940-Dec. 20,1940	May 23,1941-date**
Highway #17*	R	15,600	Oct. 7,1940-May 20,1941	May 20,1941-date
Four Mile Creek	R		Oct. 4,1940-May 20,1941	May 20,1941-date

*Tidal or tidal influence
**Not continuous record

The two lower gages are tide gages. The gage at Lenuds Ferry is under the influence of the tides and, therefore, at low stages it is not representative of true discharges. The gages upstream from Lenuds Ferry are above the tidal influence.

2. Rating curves. Discharge rating curves are available or stream gaging measurements were made to define rating curves for all stream gaging stations below Santee dam. The Lenuds Ferry rating curve was defined by four discharge measurements; three of which were taken during discharges of 5000 to 9000 cubic feet per second and one measurement at low tide during a period of low discharge.

3. Discharge records. Discharge records for Wilson Landing for the periods May to Dec. 1941 and April to July 1942 were computed from daily staff gage records supplied to this office by the Moran Engineering Company. During periods when these records were not complete, but Eutaw Landing records were available, the latter were reduced to Wilson Landing by a direct drainage area relation and by applying a one day lag. Discharge records for the "delta" region were computed using drainage area relations by the following methods: (a) from Lenuds Ferry for days when reliable records were available, i.e., during periods of high flow, (b) from Eutaw Landing by relationship of intervening drainage areas between Wilson Landing, Eutaw Landing, and "the delta", (c) by a direct drainage area relation to Wilson Landing for the remaining days. The discharge as given for the "delta" is the total fresh water discharge of the two branches of the Santee River.

4. Flood frequency curves. As shown on Plate 1 Appendix A, natural and modified peak discharge frequency curves were drawn for the Santee River below Santee dam. These curves are based on discharge records from the U. S. Geological Survey gaging station at Ferguson, South Carolina for the period from December 1907 to June 1941. The natural flows at Ferguson from the beginning of record until 1939 when Saluda dam began operation, were adjusted for the probable effects upon the stream flow at Ferguson, if Saluda dam had been in operation for the entire period of record. From September 1929 to June 1941 the flows as they appeared in the records were used. General discharge relation

curves were drawn between Ferguson and Silverstreet, a U. S. G. S. gage on the Saluda River just above Saluda reservoir, Lake Murray, for the period from January 1927 to September 1929. A general discharge relation curve between gages above and below Saluda dam (the Saluda River at Silverstreet and Columbia) were constructed for the period after the construction of the dam. By the use of these curves discharge records at Silverstreet were estimated from the Ferguson record, the theoretical storage of Lake Murray computed, an allowance for valley storage applied, and the resulting reduction in discharge was subtracted from the Ferguson records to give the computed discharge at Ferguson as modified by Lake Murray storage.

5. Two modified peak discharge-frequency curves were drawn. Both are based on operation of the Santee-Cooper development after the installation of the sixth generating unit. The curve based on the operation of Santee-Cooper utilizing all flows up to and including maximum turbine capacity, 30,000 cubic feet per second, will give the maximum expected reduction in peak discharge. On the basis of such operation a tabulation showing the greatest anticipated flood reduction afforded by the Santee-Cooper development is given in TABLE 1 of the report. It is assumed that the South Carolina Public Service Authority will operate the development (Santee-Cooper) to utilize all flows up to maximum turbine capacity before releasing water from the Santee reservoir. Since no storage is allotted for flood control and whatever reduction of flow experienced on the Lower Santee River is due to diversion, the future operation of the power plant will determine the modified Santee River discharge.

6. In order to ascertain probable duration of flow of 7000 cubic feet per second (approximate amount necessary to keep lower delta conditions favorable for continuation of fresh water plant growth) related from Santee dam duration-frequency curves were drawn with 7000 cubic

feet per second as the parameter for both maximum turbine capacity and 57.5 percent load factor (see Plate 1 Appendix A). From these curves it may be predicted that on an average of once a year for a period of at least seven consecutive days a flow equal to or exceeding 7000 cubic feet per second will be released from the Santee dam, if it is operated at maximum turbine capacity, 30,600 cubic feet per second; and for a period of at least 19 consecutive days, if operated at 57.5 percent load factor, 16,000 cubic feet per second.

7. Black River relationship. In order to ascertain probable run-off from the intervening drainage area between Santee dam and the mouth of the Santee River discharge records of the Black River, at Kingstree, South Carolina, drainage area 1240 square miles, were studied. The Black River watershed adjoins the Santee and Congaree Rivers and is similar to the terrain of the Lower Santee River watershed, i.e., both have large swampy areas conducive to large volumes of valley storage and long periods of moderate run-off. A volume frequency curve for the Black River at Kingstree is shown on Plate 1 Appendix A. By means of this curve it is possible to determine the approximate average daily run-off from the intervening area between the Santee dam and the mouth of the Santee River, drainage area 790 square miles, for floods of various frequencies. As stated in the report in paragraph 79 an average daily run-off of 1200 cubic feet per second will be equalled or exceeded on an average of once a year, 2400 cubic feet per second once every two years, and 4100 cubic feet per second once every ten years; all extending over a period of one month. A peak discharge frequency curve based on discharges at Kingstree, South Carolina, but converted to run-off from lower Santee basin gives a peak discharge equal to 6700 cubic feet per second to be equalled or exceeded on an average of once every ten years as compared with a daily average of 4100 cubic feet per second. The effects of valley storage, which on the Lower Santee River is of consider-

able magnitude will have a tendency to lower the peak discharges as determined from the watershed above Kingstree, South Carolina, an area with similar properties but nevertheless, a natural drainage area containing factors conducive to slightly higher values of peak discharge than will be expected on the Lower Santee River.

WAR DEPARTMENT

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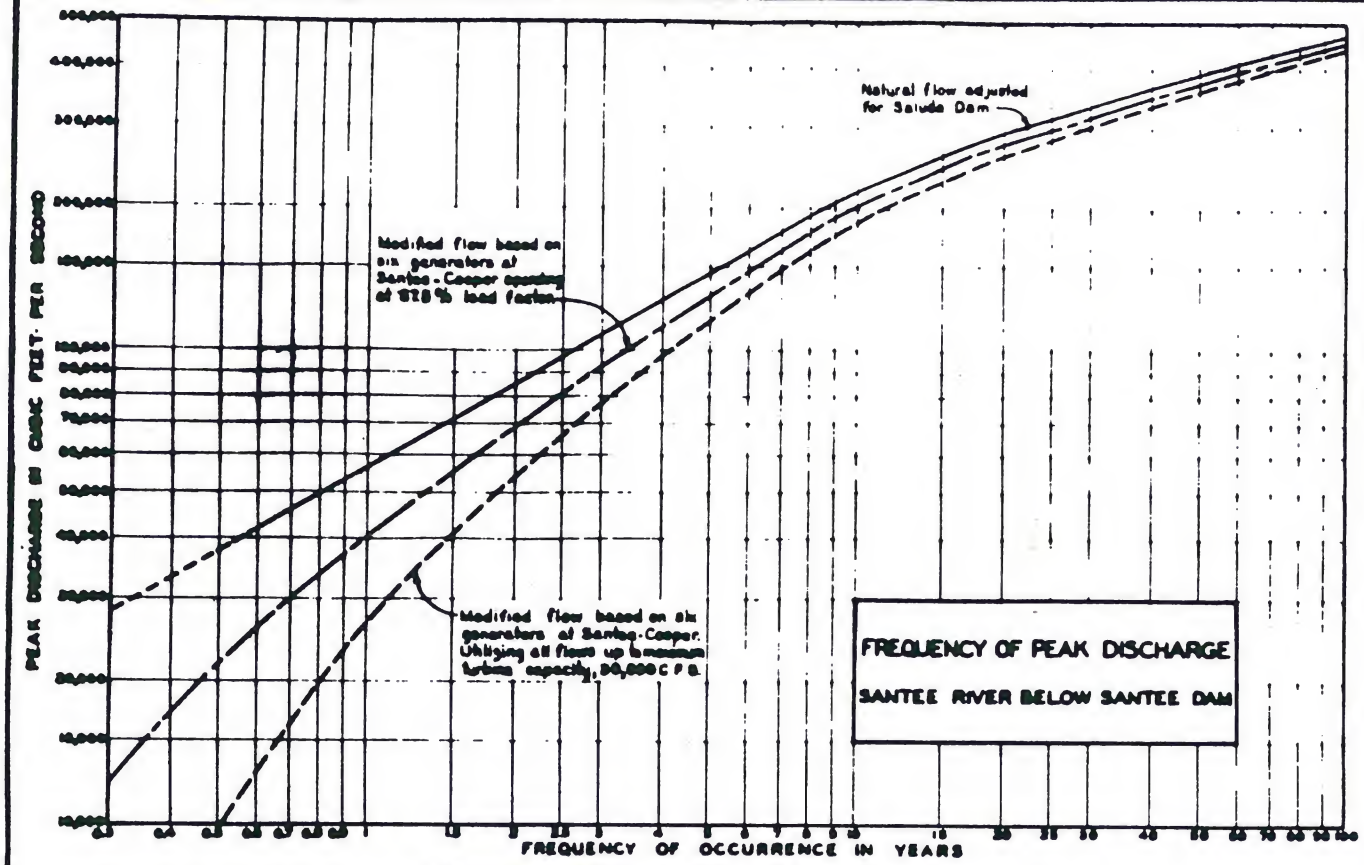

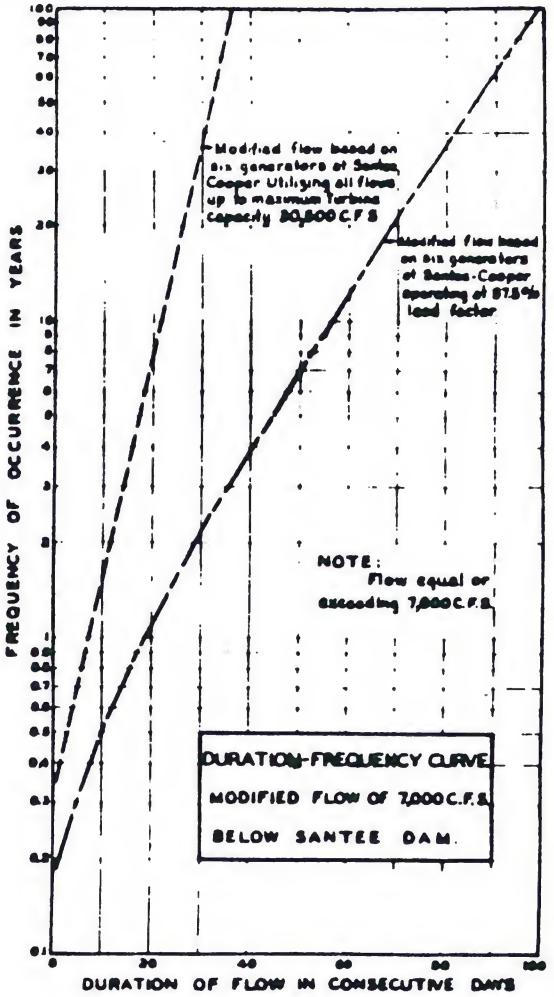

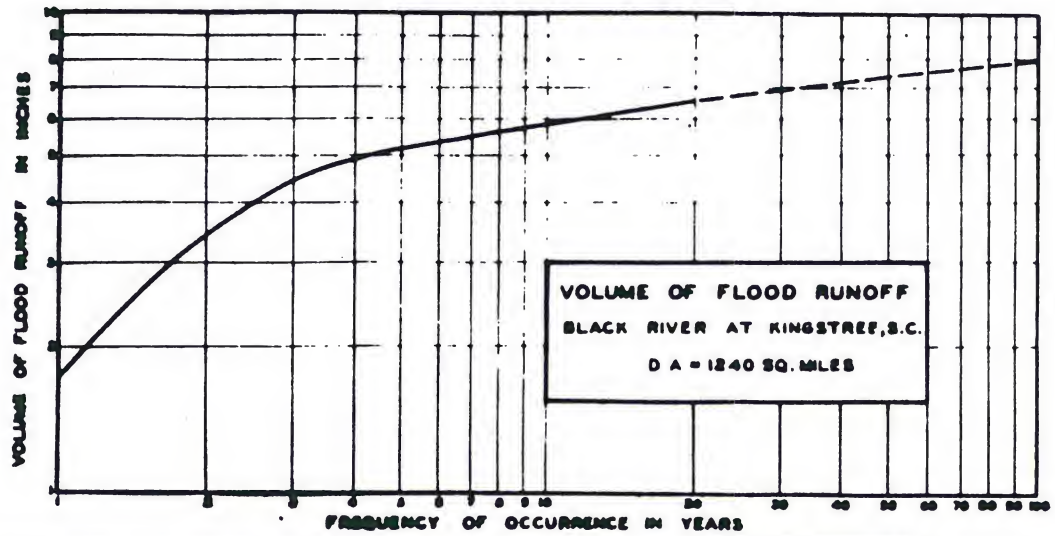

SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

FLOOD FREQUENCY CURVES

SANTEE RIVER BELOW SANTEE DAM

BLACK RIVER AT KINGSTREE, S. C.

SCALES AS SHOWN

U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942

DRAWN BY: J.S.C.

FILE NO. 7-179 (48-46)

TO ACCOMPANY REPORT DATED SEPT 30 1942 SUBMITTED IN COMPLIANCE WITH SECTION 8 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 2, 1941 BY THE U.S. SENATE COMMITTEE ON COMMERCE.

APPENDIX B

SALINITY

1. Standard. Salt-content, or salinity, of water samples is expressed as a percentage of that found in sea water. This standard was chosen because the salt concentration is so large that this method is practical and it seemed more intelligible to laymen than expressing the salt content in parts per million. Both standards are used in the United States Department of Agriculture Technical Bulletin 634, "Food of Game Ducks In the United States and Canada" by A. C. Martin and F. M. Uhler.

2. Salinity of sea water. On page 23 of the United States Geological Survey Bulletin 770, "The Data of Geochemistry" by Frank Wigglesworth Clarke, the statement is made that the average salinity of ocean water is not far from 3.5 percent (i.e., 35,000 parts per million) and this is the ratio used in this report. This value is quoted by several other authorities.

3. Uniformity of ratio of salts and density of sea water. Another attribute of sea water is the uniformity of the ratios of the various salts found regardless of the concentration. This is of importance as it enables the investigator to titrate for chlorine and determine the total salts by ratio. The table on page 127 of the above mentioned book on geochemistry shows the proportions of the various salts found by 24 investigators and they are remarkably uniform. The percentage of chlorine (by weight) found in column 4 (55.292%), derived by W. Dittmar, is generally accepted as the standard for comparison. On page 26 of the same book the density of sea water is said to be 1.027.

4. Determination of salinity. - Salinity was determined by chemical titration with one-tenth normal solution of silver nitrate using saturated solution of potassium chromate (K_2CrO_4) as the indicator. The procedure used, which is explained after this summation, is as follows:

Measure 10 cubic centimeters of water sample
Add 2 drops of potassium chromate
Add .1 N silver nitrate solution until color changes
Multiply the number of cubic centimeters of silver nitrate used by 1.76 and result is the salinity of the sample expressed as percent of sea water.

5. Silver nitrate is colorless. When enough silver nitrate is added to the water sample containing 2 drops potassium chromate to form a permanent red color it indicates that all the chlorine has combined with silver and that any additional silver nitrate added would go to help form silver chromate.

6. The atomic weight of silver nitrate ($Ag\ N\ O_3$) is 169.9. To make a .1N solution 1699 grams of pure crystaline silver nitrate are dissolved in enough distilled water to make a liter (1000 c.c) of solution. The atomic weight of chlorine is 35.45 making each gram of normal solution of silver nitrate equivalent to .03545 grams chlorine and consequently each gram of .1N solution equivalent to .003545 grams chlorine. Standard texts referred to dropped the last figures making each cubic centimeter of .1N solution equivalent to .0035 grams of chlorine. The density of the solution is 1.013 and cubic centimeters and grams are used interchangeably. The grams of salts in a 10 gram water sample are designated by S. Then $S = \frac{100.00}{55.292} \times \frac{1.000}{1.027} \times .0035 \times$ cubic centimeters of silver nitrate used. The first term, converting chlorine to total salts, has been explained previously; the second term, involving the density of sea water, converts a measured 10 cubic centimeters sea water to 10 grams. The product of the first two terms, which is considered a constant in these computations, is 1.76. If the sample is sea water, 10 grams contain .35 grams of salt since computations for this report are based on the assumption that sea water has 3.5 percent salts. The third term in the equation (.0035) divided by .35 gives .01. Then if the concentration of salt is to be expressed in percent of sea water the equation becomes percent sea water = 1.76 x .01 x grams silver nitrate used x 100.

7. Acidity and alkalinity. Chemical acidity or alkalinity is measured by the hydrogen-ion concentration expressed in parts per million. A value of 7.0 is neutral with lower concentrations indicating acidity and greater values alkalinity. In Part II of the report by G. Robert Lunz, Jr. on "Oyster Culture with Reference To Dredging Operations In South Carolina" a table is given showing pH values in the Cape Romain region. Values range from 6.6 or less (6.8 was the lower limit of the indicator used) for fresh water to 8.4 for approximately 100 percent sea water. The author makes the statement that "throughout the investigation it was found that there was a close correlation between the freshness or saltiness of the water and the degree of acidity or alkalinity". Both the tabular values and the author's general statement are borne out by the investigations made from October 28 through November 5, 1941, when water ranging from fresh to one part sea water had pH values of from a low of 6.8 to 7.0 and water with a salinity equal to from 15 percent to 50 percent sea water had pH values ranging from 6.8 to 7.8. This indicates that acidity cannot increase because of dilution which increases the salinity of the water. As acid conditions normally have a retarding effect on plant growth there should be no ill effects from a decrease in acidity.

8. Turbidity. Turbidity results from the presence of silt, clay or other fine particles in the water. Turbidities as high as 50 to 100 parts per million make water muddy. Values ranged between 7 and 140 parts per million during the investigation from Oct. 28, 1941, through November 5, 1941. There was no clear relationship between salinity and turbidity. However throughout the investigation it has been noticed that increased salinity has resulted in clearer water.

9. Kinds of salinity determinations. Two kinds of salinity determinations were made for this report, namely soil-water salinity in the marshes and the salinity of the water in the rivers.

10. Soil-water salinity. - To determine the salinity of soil-water samples were collected from holes dug in the marshes. Four series of determinations were made in the lower portion of the delta, samples being taken within a few feet of the same point but not in the same spot during the successive determinations. TABLE 1B is a condensation of the data obtained, each item in this table being the average of a number of samples taken in the same general vicinity. The divergence of the individual values from the average shown is apparent. Where necessary the samples in one general vicinity were broken into two or more groups to accomplish this. The transition is not smooth but the table indicates the reduction of soil-water salinity from the mouth upstream and also the great increase in soil-water salinity with inversion. The marshes are inundated daily, for the most part, so soil-water salt content probably increases greatly by evaporation. Soil-water samples were taken within a few hundred feet of the river banks but the marshes are flat so the same salinities undoubtedly occur farther inland.

TABLE 1 B

SOIL-WATER AND COINCIDENT SURFACE SALINITIES
IN PERCENT SEA WATER

November 1941			April 1942			May 1942			July 1942					General
Date	Soil-water salinity	Max. surface water salinity	Date	Soil-water salinity	Max. surface water salinity	Date	Soil-water salinity	Max. surface water salinity	Date	Soil-water salinity	Max. surface water salinity	No. of samples	Miles above mouth	Location
							SOUTH SANTEE RIVER							
13	57.8	55	3	50.6	7	--	----	--	24	80.8	90	9	1.9	Drum Island
13	52.8	40	6	74.6	0	--	----	—	24	68.2	80	9	3.0	Murphy Island
14	10.7	30	6	5.2	0	21	46.7	50	24	46.3	75	11	3.7	Grace Island
14	10.7	30	6	7.4	0	--	----	--	24	38.7	75	8	3.7	Grace Island
25	15.0	60	7	4.0	0	—	----	—	7	30.0	50	5	4.1	Cedar Island
14	42.4	20	-	—	-	--	----	—	24	56.1	75	10	4.4	Murphy Island
14	25.6	20	6	22.0	0	—	----	—	25	59.2	75	5	4.7	Murphy Island
15	6.4	20	6	14.3	0	25	30.1	40	8	28.8	45	4	4.7	Murphy Island
15	4.2	20	6	3.1	0	25	19.0	40	8	28.0	40	7	4.9	South bank
15	3.1	20	7	1.6	0	23	24.4	40	8	24.2	40	9	5.3	Goat Island
15	1.9	20	-	---	-	23	23.5	40	7	24.4	40	7	5.4	Goat Island
17	4.4	20	-	---	-	23	12.9	40	27	32.5	60	7	6.0	Brown Island
—	---	--	-	---	-	23	30.4	35	--	----	—	3	6.6	North bank
25	8.3	35	-	---	-	--	----	—	--	----	--	7	6.8	South bank
—	---	—	-	---	-	23	29.1	35	27	38.4	50	3	6.8	North bank
—	---	—	-	---	-	23	15.0	35	--	----	--	4	6.8	North bank
19	5.7	30	-	---	-	--	----	--	—	----	--	5	7.1	North bank
							NORTH SANTEE RIVER							
26	11.8	40	11	5.7	0	--	----	--	27	29.5	50	6	5.9	South bank
26	12.8	40	--	---	-	--	----	—	27	25.5	50	4	5.9	North bank
—	----	—	—	---	-	30	14.8	25	27	45.2	50	2	5.9	North bank

11. Stream salinity. It was found that the greatest salinity in the stream occurs during slack water immediately following high tide. The salinity is greater at the bottom than at the top, the average difference being 19 percent during May-July, 1942. However, the surface water inundates the marshes and consequently its salinity is of most interest in this study. The maximum salinities at the surface during the tidal cycle are plotted on PLATES 1 and 2 of this appendix. Actual observed salinities are plotted as circles and extrapolated salinities are plotted as squares. The extrapolations are based on actual salinity observations through a full tidal cycle during daylight hours on other dates.

12. Isochlors and related data. Based on the data plotted on the above graphs, the isochlors (lines of equal salinity) shown on PLATES 3 and 4 of this appendix were plotted. A series of intermediate working curves (in which miles above mouth were plotted against salinity) were drawn for each day on which salinity observations were made to determine the exact location of the selected percentages of salinity. These are not shown. As indicated by the data plotted on PLATES 1 and 2 of this appendix no salinity observations were made during the period of April 15 - May 29, 1942 and the isochlors shown for this period are based on comparisons with those obtained for periods of like discharge when salinity data were obtained. The estimated discharge of the Santee River and the average rainfall over the drainage basin below Santee dam are shown on PLATES 1-4 of this appendix. The maximum daily tide elevation, taken from the recording gage record on the North Santee River at Highway 17, are also shown on PLATES 3 and 4. Incidentally the maximum daily water surface elevations, during periods of diversion, are the same from the mouth of the stream to Lemuds Ferry. No observations were made above this point in the tidal reach.

13. The general trend of the relationship between the fresh-water inflow and salinity movement is clearly indicated by the isochlors plotted on the aforementioned plates. On the South Santee River the following conclusions seem warranted:

(1) Salinity conditions that were in effect in the general vicinity of the waterway will move upstream to the vicinity of the highway bridge. This is indicated by comparing, for example, pre-diversion conditions in June, September and October 1941 with those of December 1941, and the period from May through July in 1942. The record for June 1942 also indicates the responsiveness of salinity movement to fresh-water inflow, while the record during July and August 1941 and April 1942 shows that fresh-water conditions approach the mouth of the stream during periods with discharges of 50,000 cubic feet per second and more.

(2) The investigation was continued long enough to establish the approximate upper limit of salinity encroachment. This is indicated by the fact that the 10 percent isochlor, for example, did not reach appreciable further upstream limits in July 1942 than it did in December 1941 or June 1942. At this time discharges had been limited to license requirements for over 1 month and there had been only a short period of increased flow for over 3 months.

(3) The height of the tide has an appreciable effect on salt intrusion. This is apparent from a comparison of the isochlor and tide records, the record for July 1942 showing it especially well. The discharge was practically constant and the rainfall not great, leaving the tidal influence as the only important variable. This record indicates that the 10 percent isochlor ranges from mile 0 to mile 15 due to changes in tide height. The isochlors were drawn before the tide records were plotted. No attempt was made to modify the generalized curves for the period of April 15-May 29 for tidal influences.

14. Conditions are approximately the same on the North Santee River as on South Santee River. In using the waterway and highway

bridges as landmarks it appears that salinity is slightly less at these points in the North River, especially at the highway bridge. One reason for fresher water at the highway bridge in North Santee River is that it is over 2 miles farther above the mouth.

15. Floral map. In connection with the salinity studies, data for a floral map (PLATE 5 of this appendix) were obtained in the fall of 1941. This map shows the range of plant growth before diversion. Consequently the correlation of this map and the isochlor graphs indicates the salinity tolerance of delta plants.

16. Looking at this map it is apparent that fresh-water growth was found as far downstream as mile 3.5 on the South Santee River and mile 2.5 on the North Santee. The isochlors indicate that the surface water had a salinity equal to or greater than 40 percent sea water at these points in June, 1941, but that it was relatively fresh during the remainder of the growing season. It is likely that the soil-water was much fresher than the surface water in the stream during June. This is indicated from the data in TABLE 1 for other periods. Stream flow averaged 12,000 cubic feet per second at Ferguson for March and April.

17. Effects of diversion on flora. It was too early to completely evaluate the effects of the diversion for 1942 when field work for this report was stopped on August 1, 1942. Wildrice seemed unable to stand as much salinity as the arrowhead group. It had completely disappeared in the vicinity of mile 8 and below on the South Santee River. For some distance above this point the growth was stunted and many of the leaves scarred or dead. About one mile above the highway bridge the growth was normal. On the North Santee River wildrice died as a result of the diversion in the lower reaches

Opposite mile 12 it was still growing late in July. In the lower reaches where investigations showed wildrice growing in April but dead, after diversion, in May no evidence of a new growth was found after the release of fresh-water in June.

18. The arrowhead group of plants have about the same salinity tolerance as wildrice but their reaction to the curtailment of fresh-water was slightly different. They also died in the lower reaches when fresh water was curtailed in May after starting growth earlier in the spring. However, with the advent of the fresh-water in June new plants sprouted from the old roots. These new plants were dead when inspected in July. As a whole this group managed to survive somewhat farther downstream than wildrice but it showed severe effects from salt water, the growth being stunted and the leaves scared. This was true above points where the wildrice was only slightly affected as this group of plants had a stunted growth and scared leaves above the highway bridge.

19. The other fresh-water plants were affected about the same as wildrice and the arrowheads. These, however, are the most important plants furnishing duck food in the delta.

20. Tabulated tolerance of plants. Based on data obtained from the study of both soil-water and surface stream flow and the observed effect on plant life, TABLE 3 of the report was compiled. The values were compared with those (noted in the text of the report) for other regions. The values are not meant to be exact but are rather indicative of the salinity tolerance of these plants as observed in the field. One column gives soil-water salinities as found and the other estimated surface water salinity tolerances. As noted in the text of the report most of the plants do well in perfectly fresh-water.

21. There was also evidence of the encroachment of obnoxious plants in the region where desirable ones previously grew. As an example salt marsh cordgrass grew considerably higher upstream on the banks of the South Santee River this year than it did last.

WAR DEPARTMENT

CORPS OF ENGINEERS U S ARMY

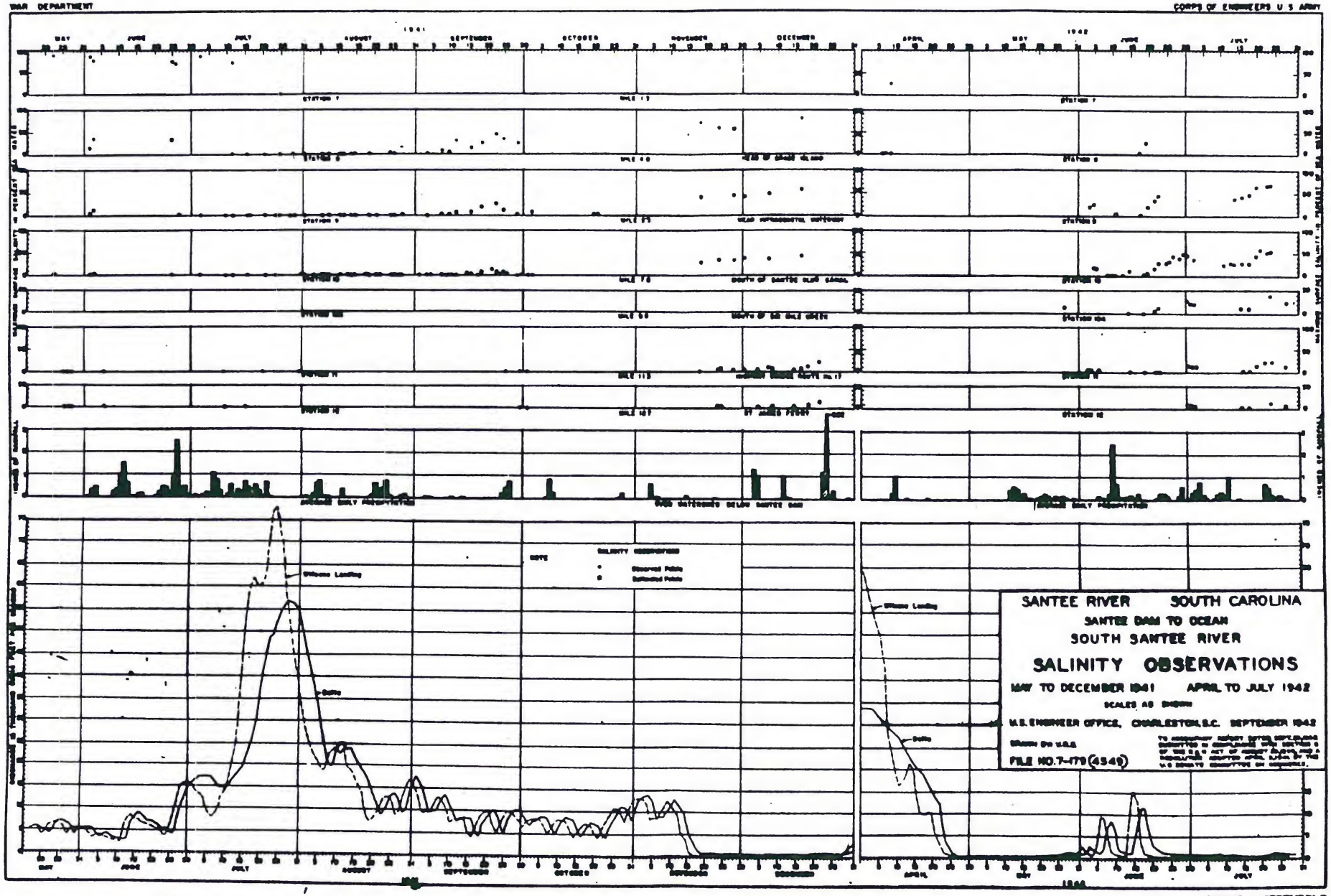

PLATE I APPENDIX B

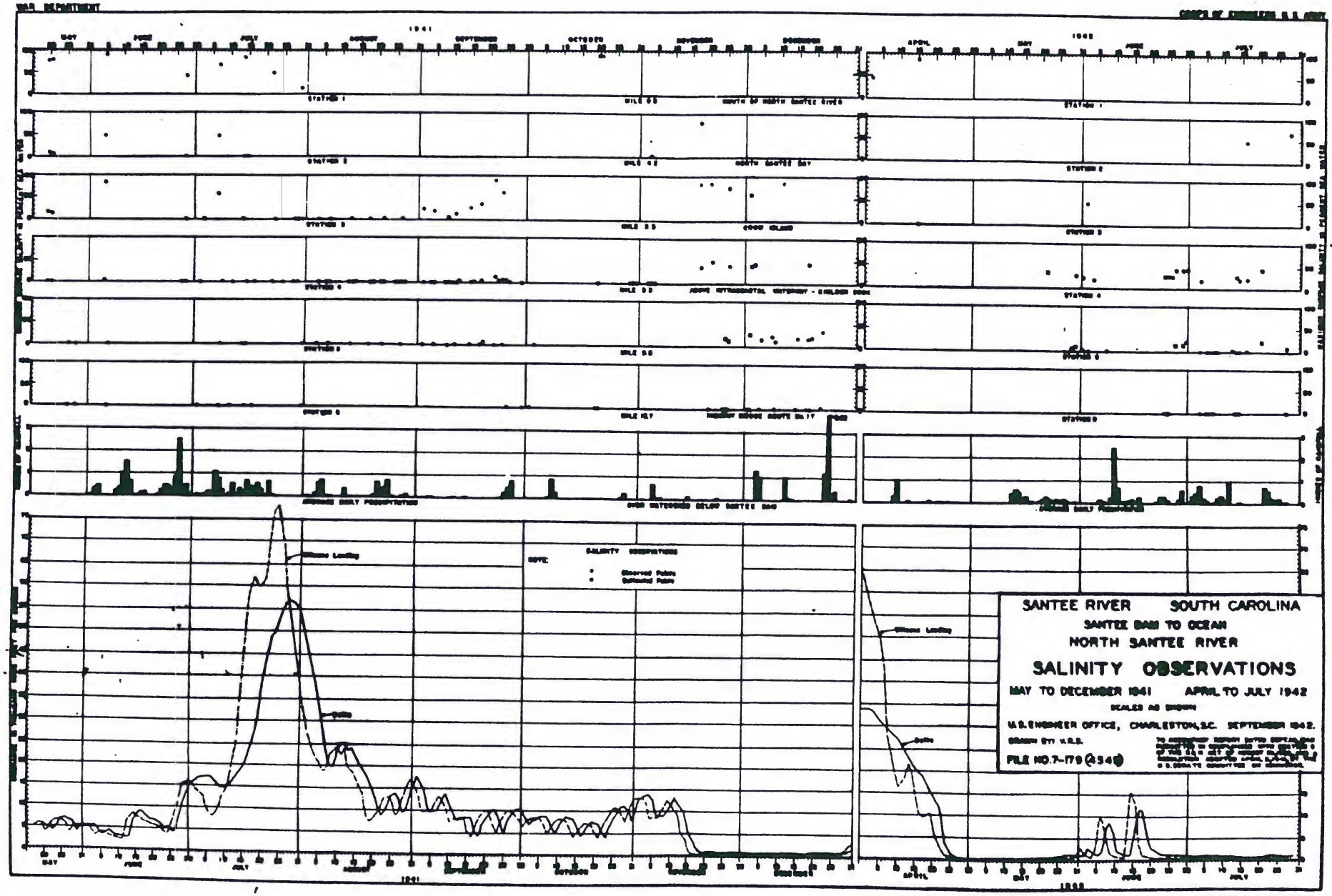

PLATE 2 APPENDIX B

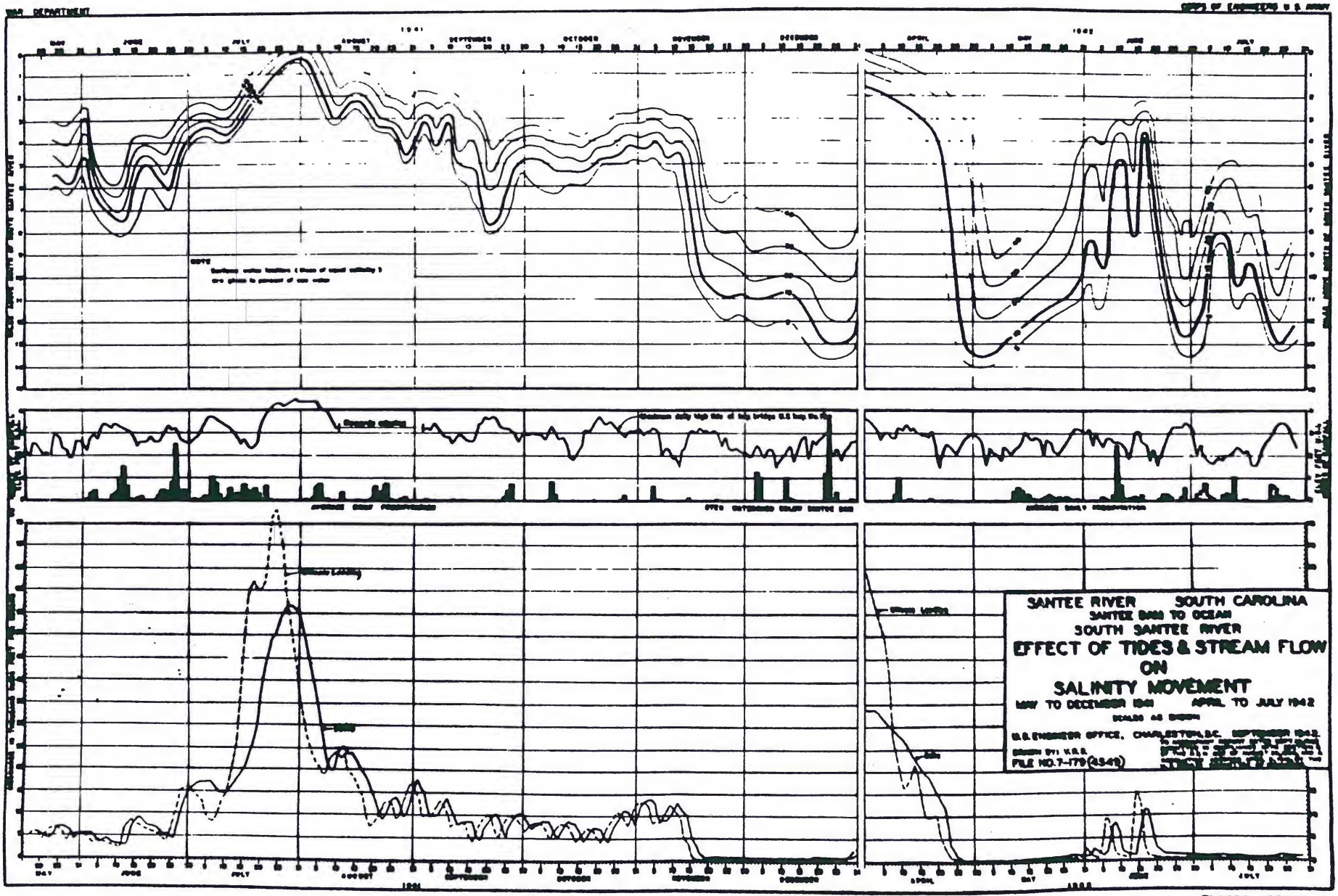

PLATE 3 APPENDIX B

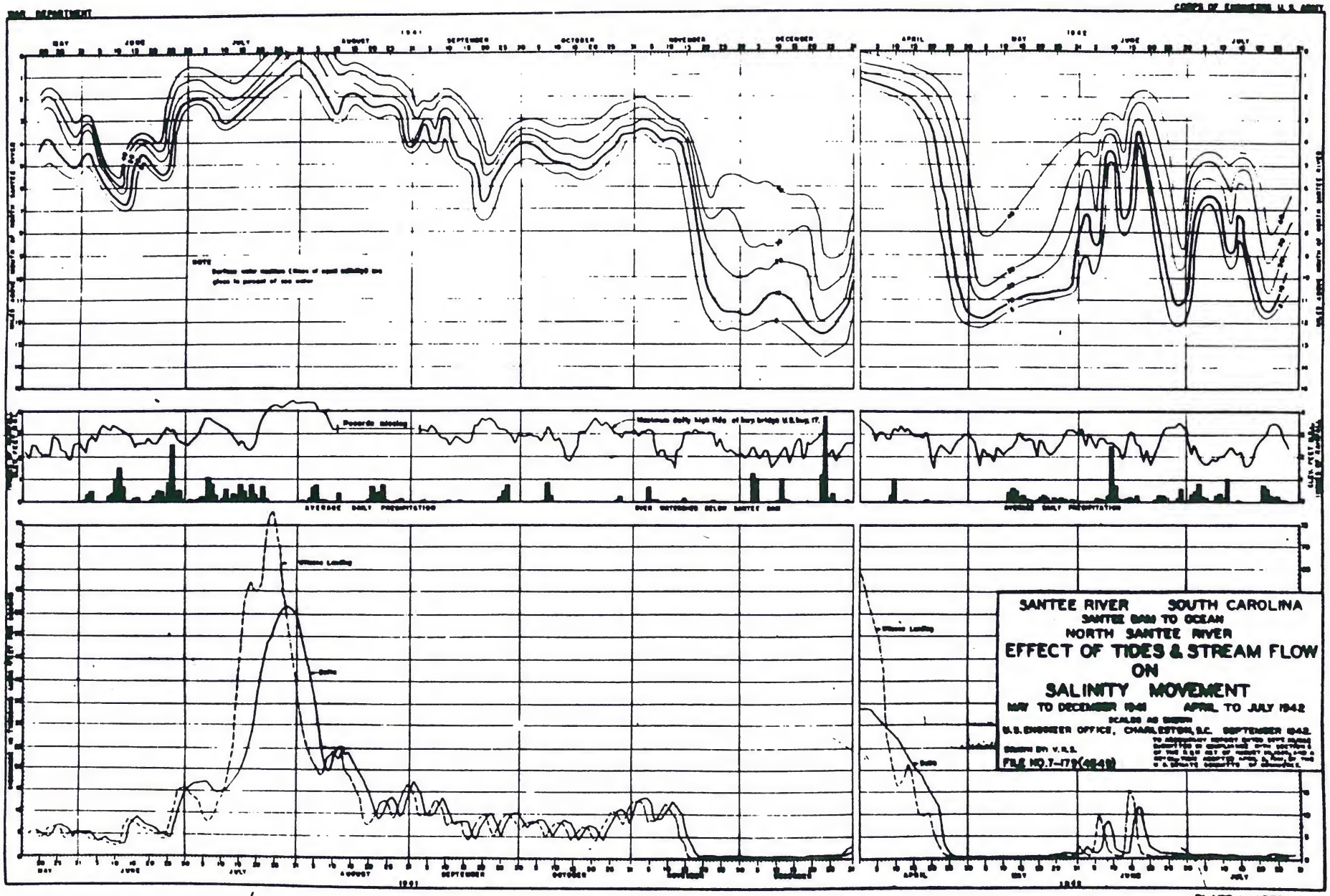

PLATE 4 APPENDIX B

APPENDIX C

PLAN OF IMPROVEMENT

1. The plan proposed consists of rebuilding the present system of dikes along both forks of the stream and along the major creeks. Dikes would have a top elevation of 6 feet above mean sea level, 2.5 feet above spring tide; a top width of 6 feet and side slopes of 1½ to 1. They would be inundated by large floods and by storm and tidal waves but past experience shows that no serious damage to the dikes results.

2. Embankment materials would be obtained adjacent to the dikes. The suitability of this material for the construction of dikes has been demonstrated by practical experience over many years. The dikes could be built either by hand tools or by light earth-moving equipment. There would be required only about 1½ cubic yards of new embankment material per linear foot of dike which means that equipment would have to be moved often and would result in a relatively high unit cost. It is estimated that unit costs would amount to 50 cents per cubic yard of embankment including an allowance of 10 cents per cubic yard for clearing and stripping. The proposed drainage structures or trunks would be similar to those now in use in the vicinity. The dimensions of the present trunks, which are wooden box culverts with flap gates, average 2 feet deep, 5 feet wide and 30 feet long. Untreated rough 3" lumber is used for their construction.

3. Enough elevations to indicate topography and the present system of dikes and canals are shown on PLATE C 1. A plan showing the proposed dike system is shown on PLATE C 2.

WAR DEPARTMENT

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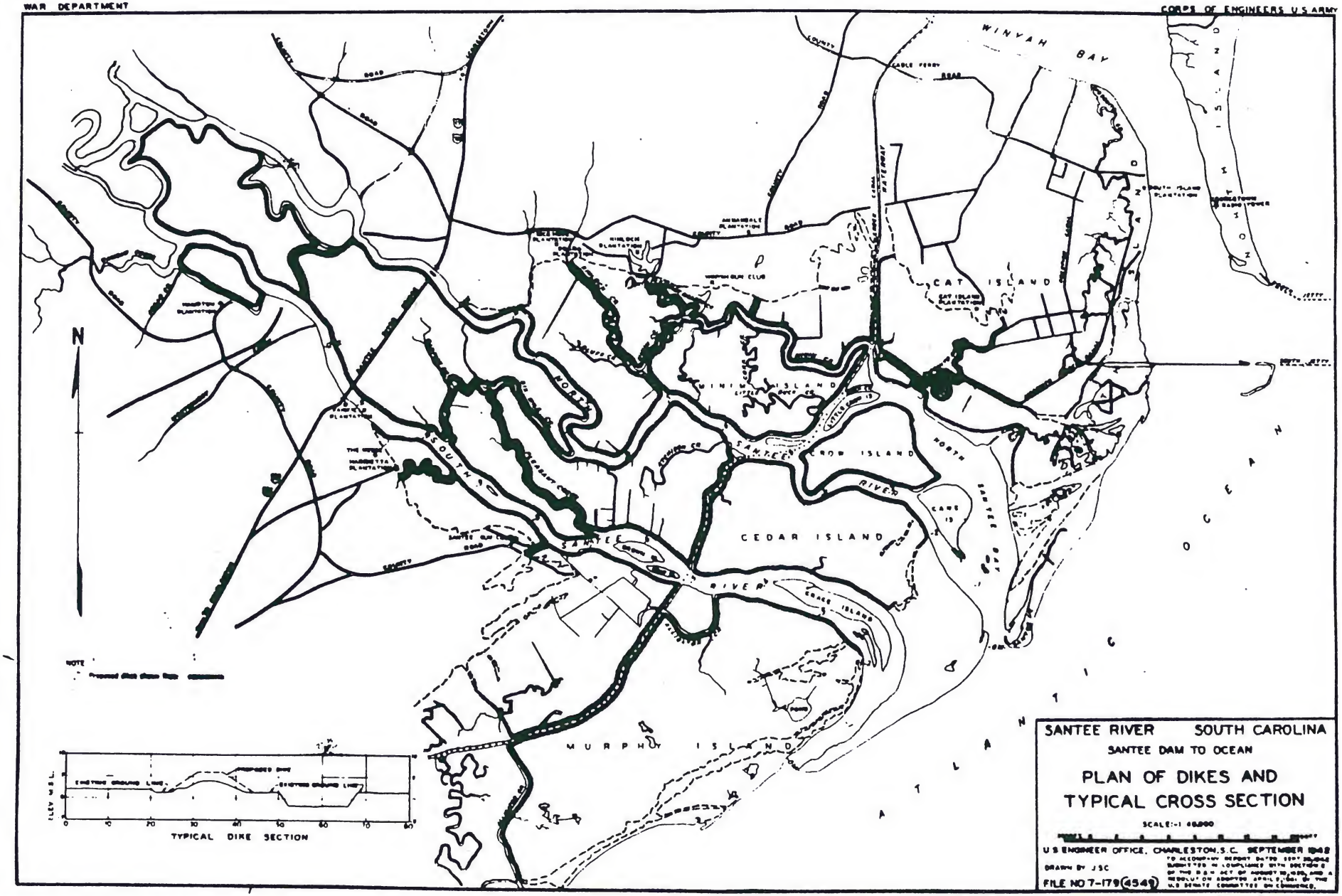


SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

PLAN OF DIKES AND TYPICAL CROSS SECTION

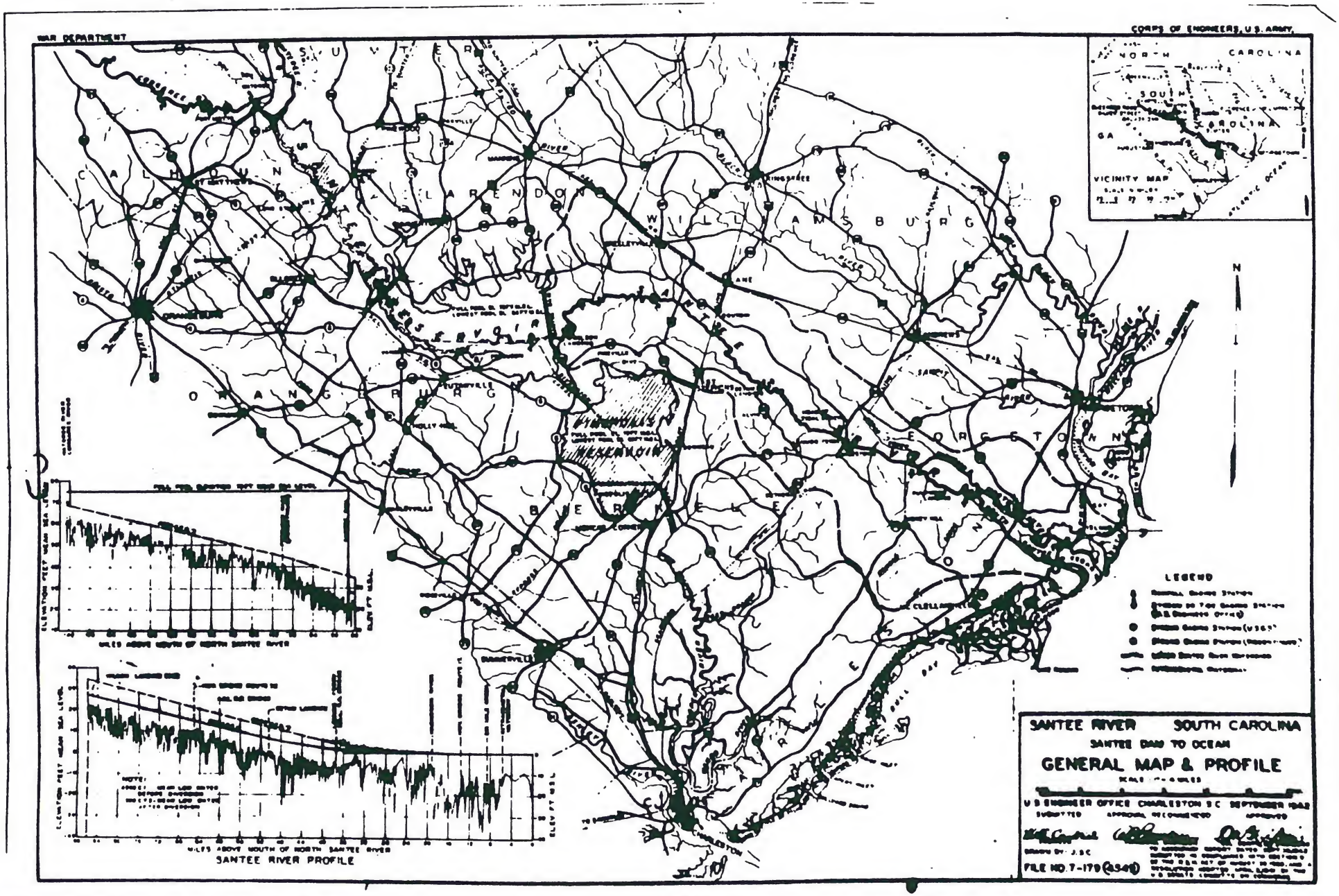
SCALE:-1 48000

U.S ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1948

DRAWN BY J.S.C.

FILE NO 7-179(4549)

PLATE 2 APPENDIX C


WAR DEPARTMENT
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NORTH CAROLINA
SOUTH CAROLINA
GA
VICINITY MAP
SUMTER
CALHOUN
CLARENDON
WILLIAMSBURG
ORANGEBURG
GEORGETOWN
BERKELEY
SANTEE RIVER PROFILE
LEGEND
SANTEE RIVER SOUTH CAROLINA
SANTEE DAM TO OCEAN
GENERAL MAP & PROFILE
U.S. ENGINEER OFFICE CHARLESTON S.C. SEPTEMBER 1942
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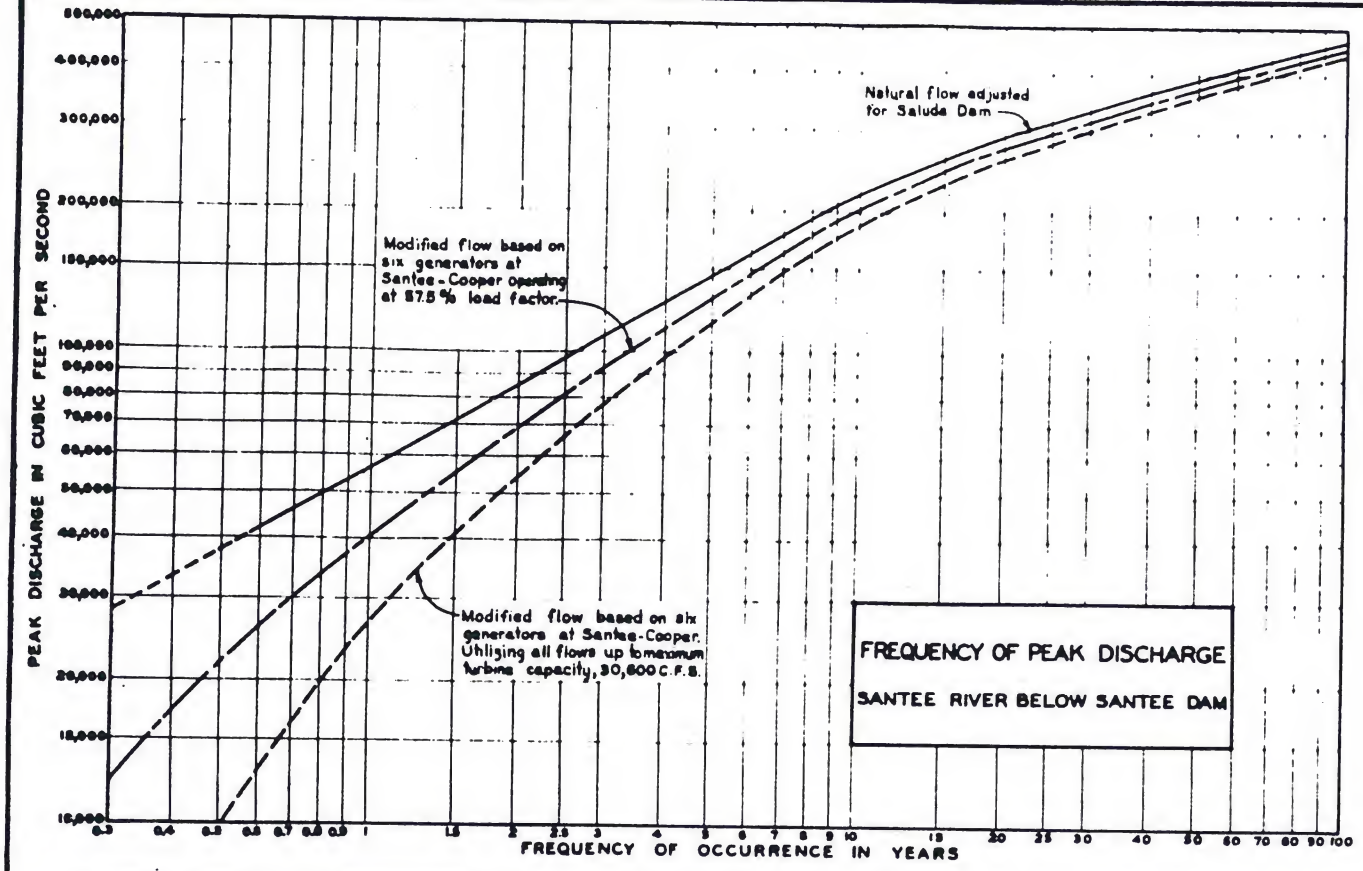
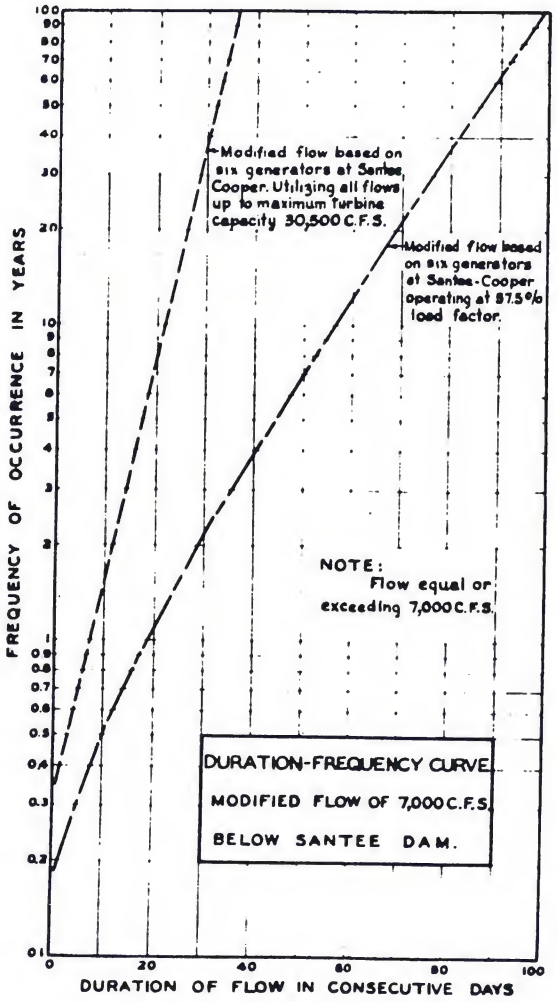
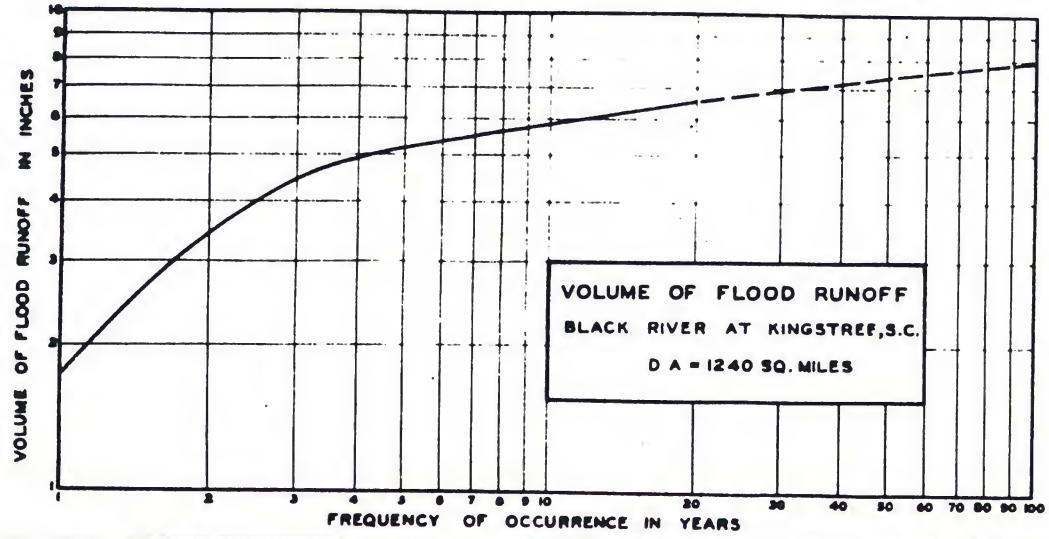
PLATE I APPENDIX A







SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

FLOOD FREQUENCY CURVES

SANTEE RIVER BELOW SANTEE DAM

BLACK RIVER AT KINGSTREE, S. C.

SCALES AS SHOWN

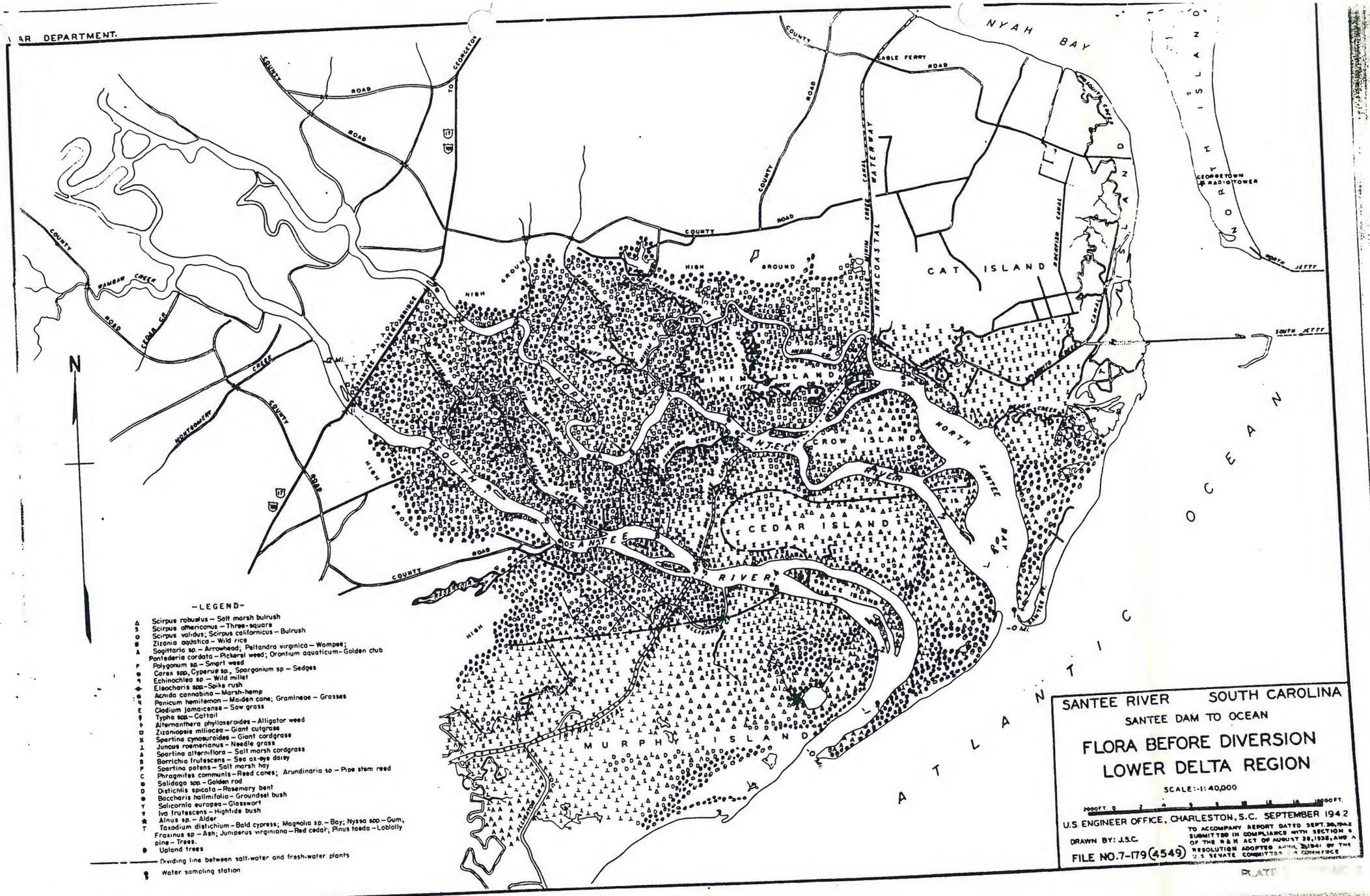
U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942

DRAWN BY: J.S.C.

FILE NO. 7-179 (4549)

TO ACCOMPANY REPORT DATED SEPT. 30 1942. SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 2, 1941 BY THE U.S SENATE COMMITTEE ON COMMERCE.

AR DEPARTMENT.



-LEGEND-

- Scirpus robustus – Salt marsh bulrush
- Scirpus americanus – Three-square
- Scirpus validus; Scirpus californicus – Bulrush
- Zizania aquatica – Wild rice
- Sagittaria sp. – Arrowhead; Peltandra virginica – Wampee; Pontederia cordata – Pickerel weed; Orontium aquaticum – Golden club
- Polygonum sp. – Smart weed
- Carex spp, Cyperus sp., Sparganium sp – Sedges
- Echinochloa sp – Wild millet
- Eleocharis spp – Spike rush
- Acnida cannabina – Marsh-hemp
- Panicum hemitomon – Maiden cane; Gramineae – Grasses
- Cladium jamaicense – Saw grass
- Typha spp – Cattail
- Alternanthera philoxeroides – Alligator weed
- Zizaniopsis miliacea – Giant cutgrass
- Spartina cynosuroides – Giant cordgrass
- Juncus roemerianus – Needle grass
- Spartina alterniflora – Salt marsh cordgrass
- Borrichia frutescens – Sea ox-eye daisy
- Spartina patens – Salt marsh hay
- Phragmites communis – Reed canes; Arundinaria sp – Pipe stem reed
- Solidago spp – Golden rod
- Distichlis spicata – Rosemary bent
- Baccharis hallmifolia – Groundsel bush
- Salicornia europea – Glasswort
- Iva frutescens – Hightide bush
- Alnus sp. – Alder
- Taxodium distichium – Bald cypress; Magnolia sp. – Bay; Nyssa spp – Gum; Fraxinus sp – Ash; Juniperus virginiana – Red cedar; Pinus taeda – Loblolly pine – Trees.
- Upland trees

Dividing line between salt-water and fresh-water plants

Water sampling station

SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

FLORA BEFORE DIVERSION LOWER DELTA REGION

SCALE:-1:40,000

2000FT 0 2 4 6 8 10 12 14 16 18000FT.

U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942

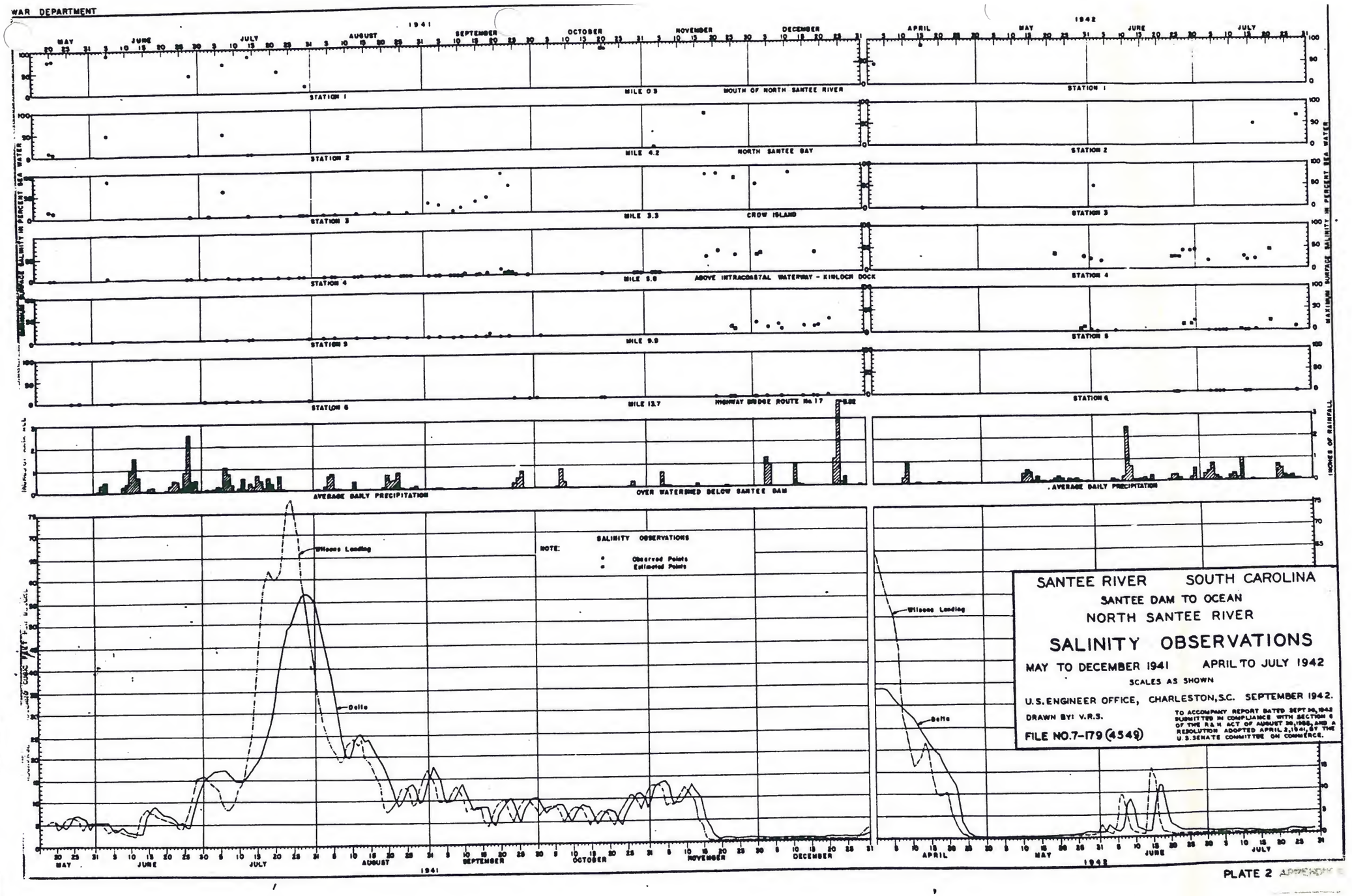
DRAWN BY: J.S.C.

FILE NO.7-179(4549)

TO ACCOMPANY REPORT DATED SEPT. 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 28, 1941 BY THE U.S. SENATE COMMITTEE ON COMMERCE

PLATE

WAR DEPARTMENT



SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

NORTH SANTEE RIVER

SALINITY OBSERVATIONS

MAY TO DECEMBER 1941 APRIL TO JULY 1942

SCALES AS SHOWN

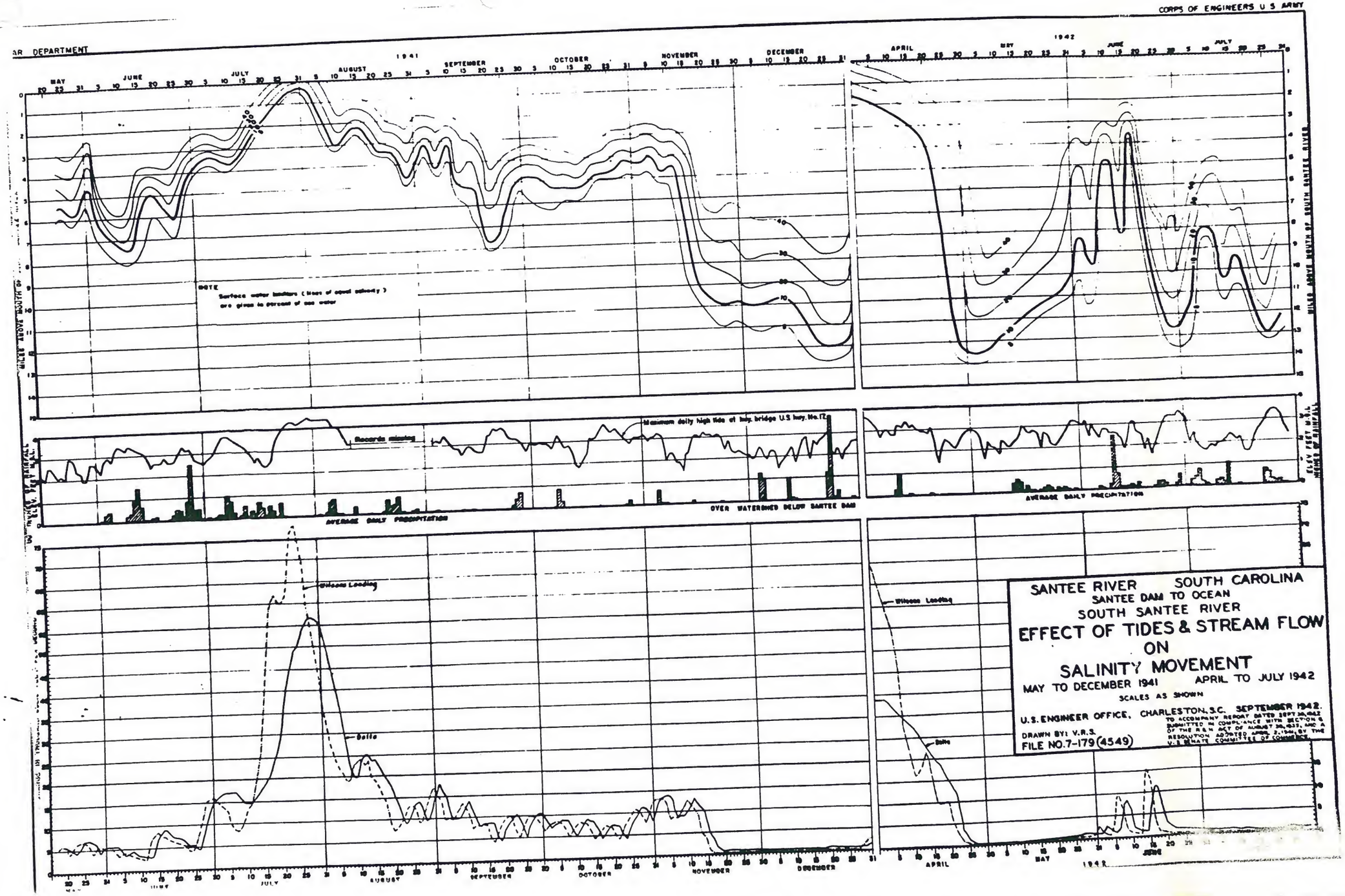
U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942.

DRAWN BY: V.R.S.

FILE NO. 7-179 (4549)

TO ACCOMPANY REPORT DATED SEPT 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 2, 1941, BY THE U.S. SENATE COMMITTEE ON COMMERCE.

PLATE 2 APPENDIX E



SANTEE RIVER SOUTH CAROLINA
SANTEE DAM TO OCEAN
SOUTH SANTEE RIVER

EFFECT OF TIDES & STREAM FLOW ON SALINITY MOVEMENT

MAY TO DECEMBER 1941 APRIL TO JULY 1942

SCALES AS SHOWN

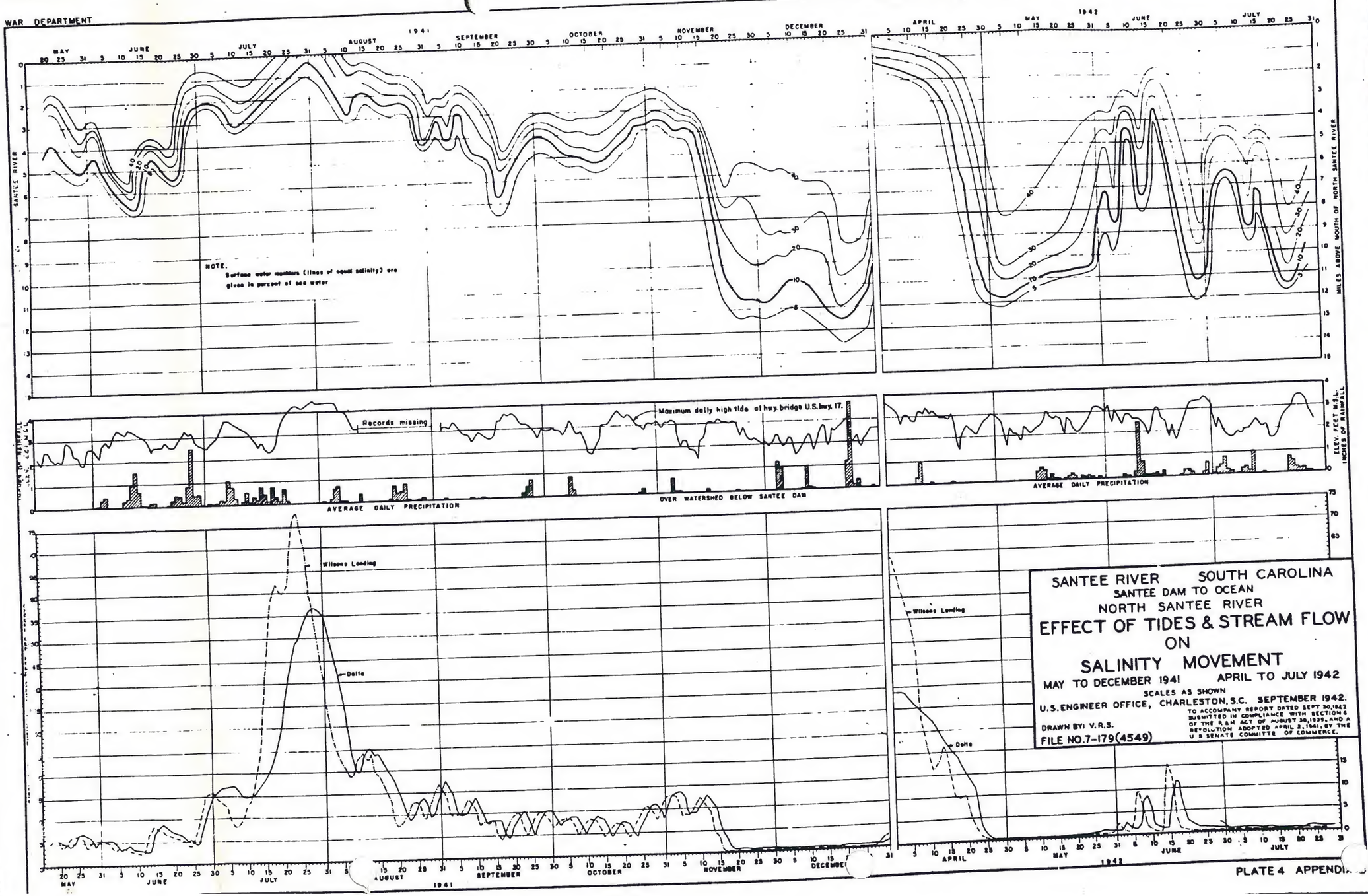
U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942.

TO ACCOMPANY REPORT DATED SEPT 28, 1942. SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED BY THE U.S. SENATE COMMITTEE OF COMMERCE, MAY 2, 1940.

DRAWN BY: V.R.S.
FILE NO. 7-179 (4549)

CORPS OF ENGINEERS U.S. ARMY

WAR DEPARTMENT



SANTEE RIVER SOUTH CAROLINA
SANTEE DAM TO OCEAN
NORTH SANTEE RIVER

EFFECT OF TIDES & STREAM FLOW ON SALINITY MOVEMENT

MAY TO DECEMBER 1941 APRIL TO JULY 1942

SCALES AS SHOWN

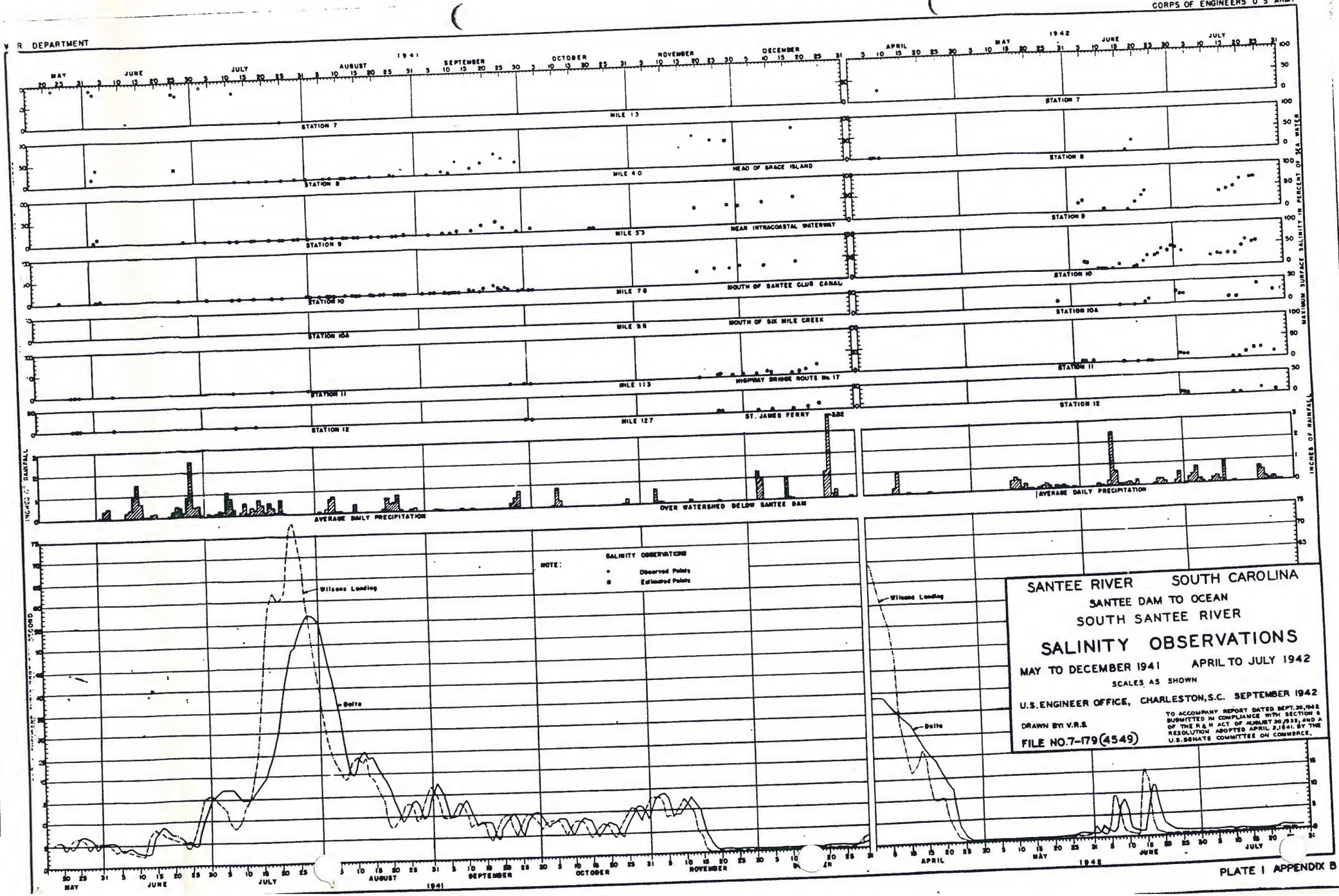
U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942.

DRAWN BY: V.R.S.

FILE NO. 7-179(4549)

TO ACCOMPANY REPORT DATED SEPT 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R.&H. ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 2, 1941, BY THE U.S. SENATE COMMITTEE OF COMMERCE.

PLATE 4 APPENDI...



SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

SOUTH SANTEE RIVER

SALINITY OBSERVATIONS

MAY TO DECEMBER 1941 APRIL TO JULY 1942

SCALES AS SHOWN

U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942

DRAWN BY: V.R.S.

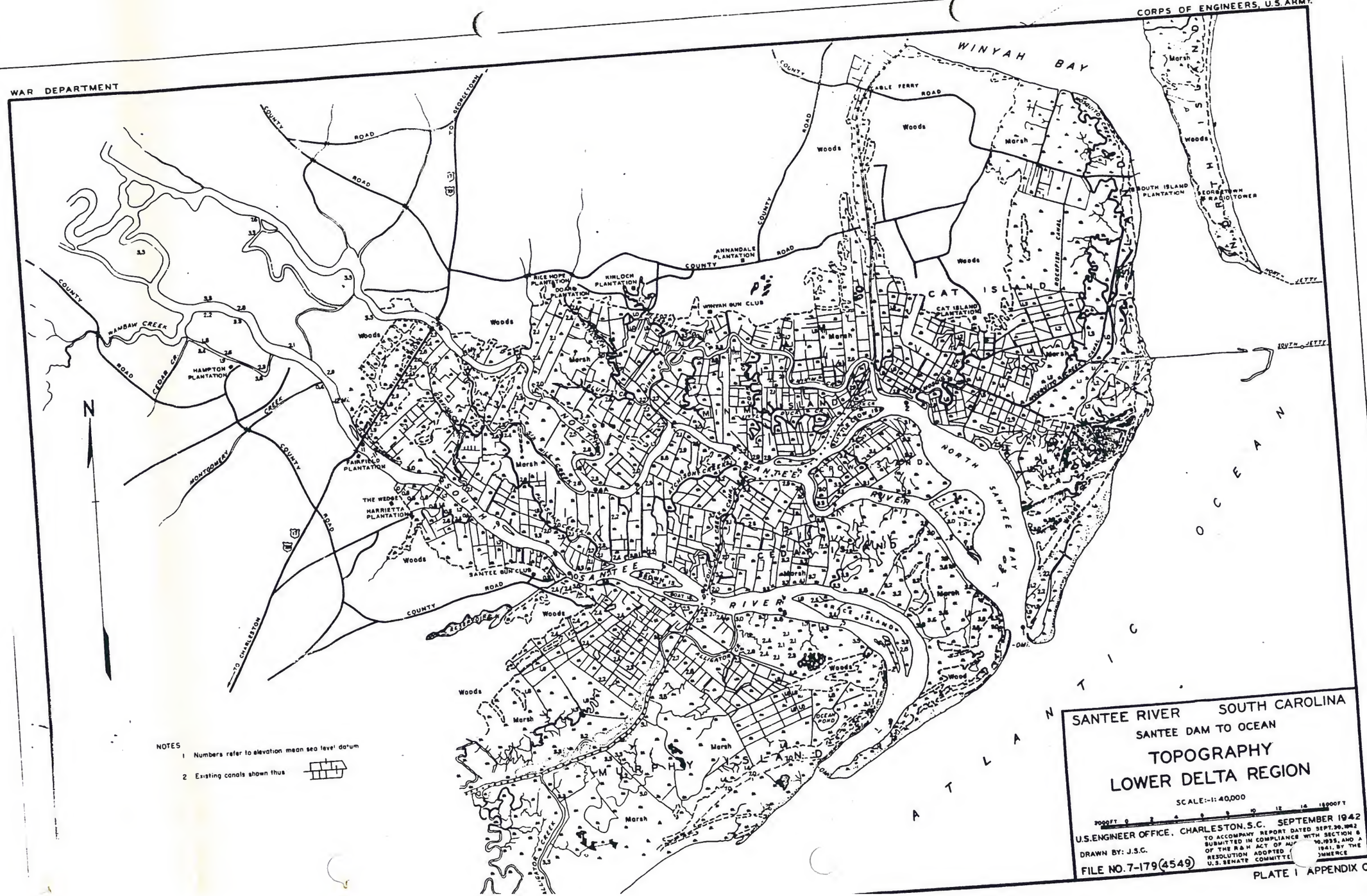
FILE NO. 7-179(4549)

TO ACCOMPANY REPORT DATED SEPT. 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AUGUST 30, 1935, AND A RESOLUTION ADOPTED APRIL 2, 1941, BY THE U.S. SENATE COMMITTEE ON COMMERCE.

PLATE I APPENDIX B

CORPS OF ENGINEERS, U.S. ARMY

WAR DEPARTMENT



NOTES

1 Numbers refer to elevation mean sea level datum

2 Existing canals shown thus

SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

TOPOGRAPHY LOWER DELTA REGION

SCALE:-1:40,000

U.S. ENGINEER OFFICE, CHARLESTON, S.C. SEPTEMBER 1942

DRAWN BY: J.S.C.

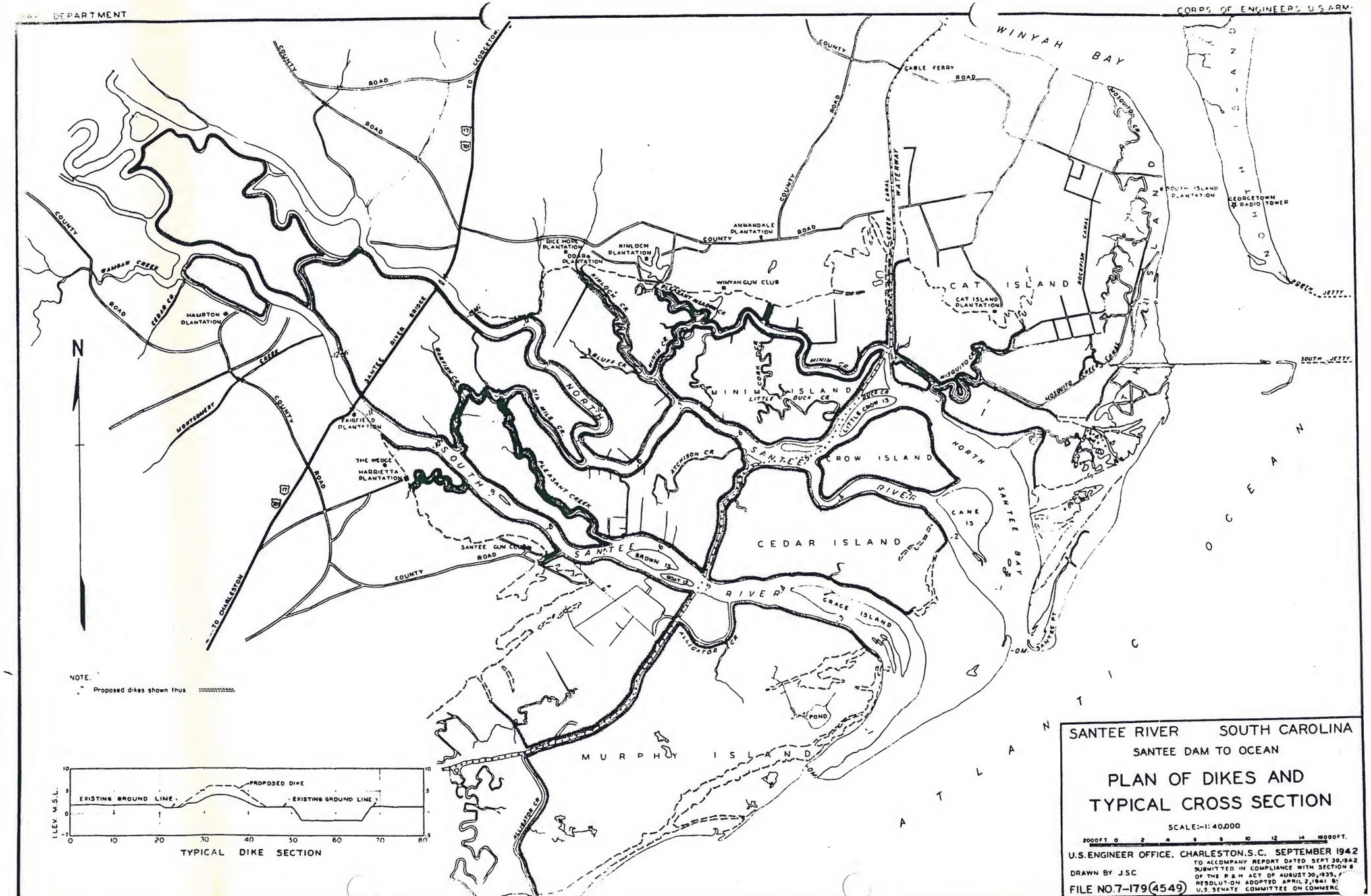
TO ACCOMPANY REPORT DATED SEPT. 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION 6 OF THE R & H ACT OF AU[illegible] 30, 1935, AND A RESOLUTION ADOPTED [illegible] 1941, BY THE U.S. SENATE COMMITTE[illegible] COMMERCE

FILE NO. 7-179(4549)

PLATE I APPENDIX C

DEPARTMENT

CORPS OF ENGINEERS U.S.ARMY



SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

PLAN OF DIKES AND TYPICAL CROSS SECTION

SCALE:-1:40,000

2000FT. 0 2 4 6 8 10 12 14 16000FT.

U.S.ENGINEER OFFICE. CHARLESTON.S.C. SEPTEMBER 1942

DRAWN BY J.S.C

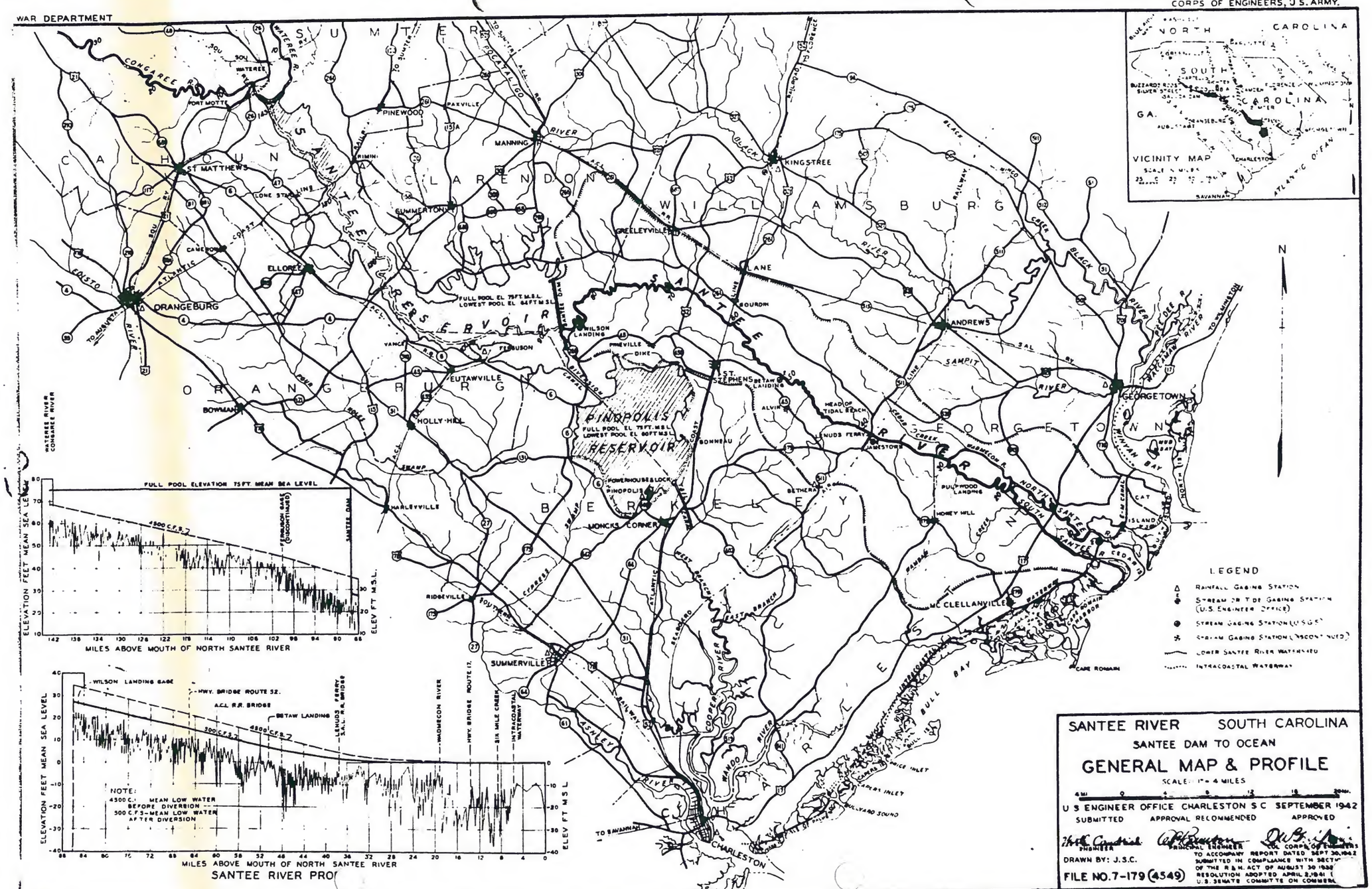
TO ACCOMPANY REPORT DATED SEPT 30,1942 SUBMITTED IN COMPLIANCE WITH SECTION 8 OF THE P & H ACT OF AUGUST 30,1935, A RESOLUTION ADOPTED APRIL 2,1941 BY U.S. SENATE COMMITTEE ON COMMERCE

FILE NO.7-179(4549)

PLATE 2 APPENDIX C

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY.



SANTEE RIVER SOUTH CAROLINA

SANTEE DAM TO OCEAN

GENERAL MAP & PROFILE

SCALE: 1" = 4 MILES

U S ENGINEER OFFICE CHARLESTON S C SEPTEMBER 1942

SUBMITTED APPROVAL RECOMMENDED APPROVED

DRAWN BY: J.S.C.

FILE NO. 7-179 (4549)

TO ACCOMPANY REPORT DATED SEPT 30, 1942 SUBMITTED IN COMPLIANCE WITH SECTION OF THE R & H ACT OF AUGUST 30 1935 RESOLUTION ADOPTED APRIL 2, 1941 BY U.S. SENATE COMMITTEE ON COMMERCE